DISCOVERY

Monthly Notebook

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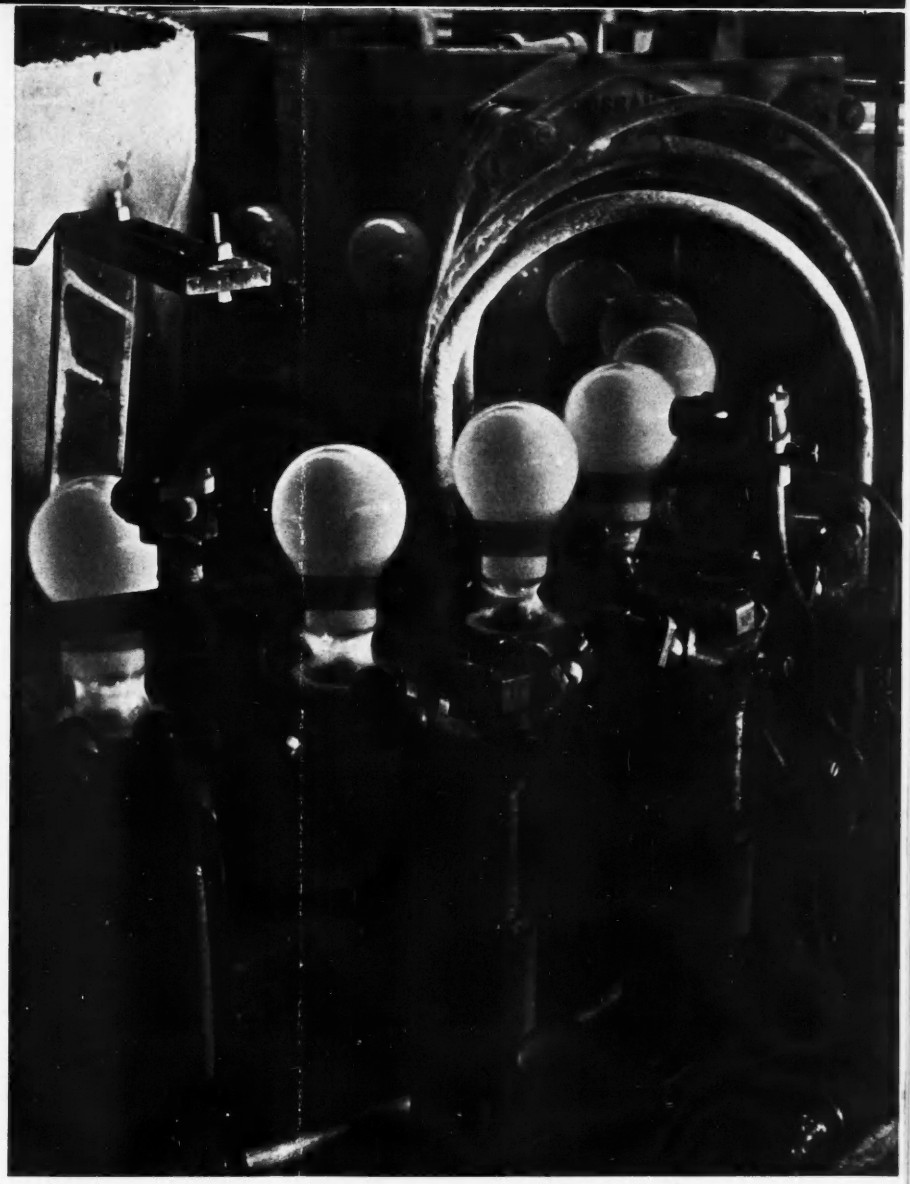

AUGUST
1952
1/6

Progress in Electronics

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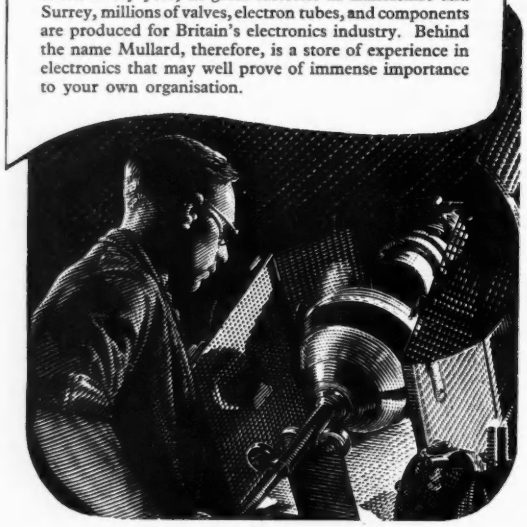

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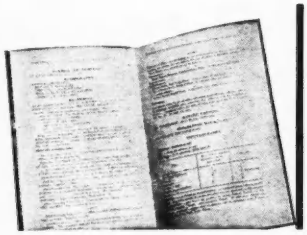

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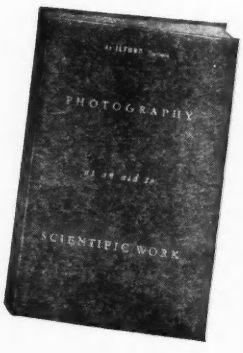

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DISCOVERY

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The Progress of Science

Fluidisation and a Projected Coal-pipeline

FLUIDISATION is a new, unbeautiful but convenient word which has not yet found its way into the dictionary. It has been coined to cover a technique which is not new but has recently developed a number of novel applications. Briefly, fluidisation means a method of making solids behave as if they were liquids. Probably the most familiar example is the discharge of grain into silos. This is done by lowering a flexible pipe into a pile in a barge or lighter and sucking at the other end with a large fan. The air percolating through the grain increases in speed as it enters the suction pipe and the grain is carried bodily along with air. At the top of the silo the air is allowed to slow down into a large chamber and the grain settles out.

This is an important method of cutting down the cost of handling solids. In industry, generally the final cost of a solid product will carry a charge for handling materials amounting to anything up to 25% of the total. Time study is used along with conveyors and other means of mechanical handling to reduce this. The fluidisation of solids is an approach to the low handling costs obtained with pumping of liquids. The technique has its limitations because there are limits to the size and density of solids which can be swept along in a current of gas at a reasonable speed. This can be appreciated if one thinks of the behaviour of a body falling freely in air, which reaches a limiting velocity when the frictional resistance of the air to its fall equals the accelerating force exerted by gravity. If the falling body is a sphere which will just pass through a sieve having 200 holes to the linear inch, the limiting speed is one foot per second if the sphere has a specific gravity of 2. Clearly a current of air moving at a speed greater than one foot per second can shift and transport such a sphere. If the sphere is of higher specific gravity, then a swifter air current will be needed to move it. In order to fluidise dense materials with air, they must be ground very small in order to reduce the power costs incurred in driving the electrically driven fans (which have to be used to create the air stream) to an economic figure. Alternatively the particles can be moved in a stream of some denser fluid—that is, denser than air—but this can only be done if the substance is not adversely affected thereby. This technique is the basis of a project—now under serious consideration—for transporting five million tons of coal a year by pipeline from Birmingham to the London area. The coal would be fluidised with water but would be of a small size suitable for power station use. The main difficulty is not the technique but the erosion of the pipeline which has to be expected. (Such erosion is encountered where gravel is pumped along with water.)

Possibilities of this nature have been realised for some time, and have led to the development, on an empirical basis, of a new branch of engineering concerned with what is called 'pneumatic conveying'. The systematic study of fluidised systems to cover material of any size or density in any kind of gas stream has only recently begun to attract the keen interest of chemical engineers. This interest arises out of petroleum processing. The yield of motor spirit from crude oil is increased by 'cracking'—that is breaking down the higher hydrocarbons present in the crude oil into lighter, more volatile ones. The earlier 'cracking' processes relied entirely on heat, but they were difficult to operate owing to the large amount of carbon formed in the process which clogged up the processing plant to such an extent that production had to stop in order to remove the unwanted carbon. The old processes were therefore far from ideal in that the plant had to be taken out of commission periodically to undergo the cleaning necessary to efficient operation. A great advance in cracking technique came with the development of 'catalytic cracking'—'cat-cracking' for short. In the catalytic cracking process the petroleum vapours were passed through a bed of spheres on which the carbon was deposited. By interrupting the flow of vapour and replacing it with air (after first sweeping out with steam) the carbon was burnt off so the cycle could be resumed straight away: the need to stop and dig the carbon out was thus completely eliminated. This technique necessitated at least duplicate catalyst chambers and complicated valve arrangements for altering the flows during the cycle.

The modern 'cat-cracking' process is made continuous by fluidising the catalyst bed. The plants which have been

built at Fawley and Stanlow have 'cat-crackers' and these form the central part of the installation. The catalyst consists of very small spheres composed of a specially prepared type of silica gel. (A factory specialising in the manufacture of this type of catalyst has been set up recently in Warrington.) The spheres are contained in a large chamber, 55 feet in diameter, the vapours sweep through it and the spheres are kept in continual motion. This is known as a 'boiling' or 'fluidised' bed, the speed of the vapour being sufficient to keep the spheres suspended without any risk of sweeping out of the chamber. The carbon deposited on them is removed by continually transferring a proportion (the transfer being effected by a stream of air) of the spheres into a separate regenerating chamber. The clean spheres leaving the regenerating chamber after their carbon coats have been burnt off are separated (from any coated spheres that remain) by means of a 'cyclone', and are then returned to the catalyst chamber. (The 'cyclone' is an empty chamber into which the spheres and air are introduced through a tangential inlet and separated by centrifugal force.)

Fluidisation has many advantages for catalytic processes of this type. In particular the problems of heat removal are simplified. The heat of burning the carbon in the 'cat-cracker's' regenerator can be used directly for raising steam and other purposes. In this country, traditional processes are being reviewed to see whether fluidisation can be applied to them. I.C.I. has since 1945 run a producer-gas plant under fluidised conditions (they call it the "moving-burden" method) and general interest is being shown by the British gas industry.

The purification of town gas from sulphur, which takes place generally in big rectangular boxes containing iron oxide, involves the digging-out of the spent oxide from time to time. It is an unpleasant process which gives gas-works their characteristic smell and is unattractive to labour. It may prove possible to do the purification in a fluidised bed of iron oxide which might be removed continuously for roasting. Lime-burning is another process which has been successfully converted to fluidised working.

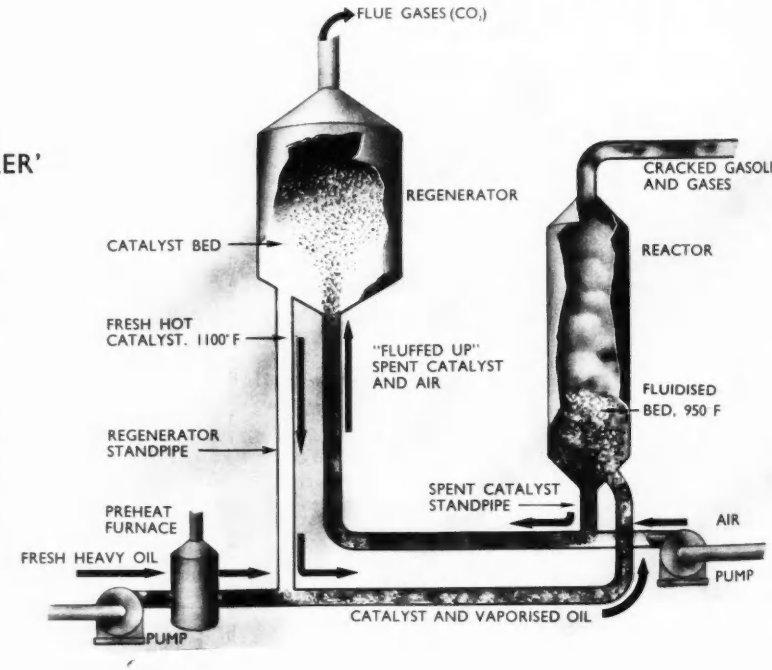
The present state of the theory and practice of fluidisation has just been discussed in London at a conference attended by Dutch, French, British and American chemical engineers. America has naturally tended to corner the know-how of fluidisation technique as applied to oil refining, so it was particularly pleasant to find that three experts from the other three nations represented had plenty to contribute to the pool of ideas. Popular approval of fluidisation is likely to become manifest when the Government allows the new 'cat-crackers' to produce 'premium' petrol, that is petrol with a higher octane number than 'Pool', which all post-war cars, with their higher compression ratios, await.

A New Vitamin?

JUST forty years have gone by since the clear modern concept of vitamins came on the scene to revolutionise ideas about diet and nutrition. For it was the year 1912 which saw the start of the work which "began to reveal the significance of accessory food factors, or *vitamins* as they later came to be called", to quote the words of Prof. F. G. Young, who is the present occupant of the chair of biochemistry at Cambridge which the great vitamin pioneer, Sir Frederick Gowland Hopkins, first filled with

FLUIDISATION IN A MODERN 'CAT-CRACKER'

The catalyst in the modern 'cat-cracker' is in the form of small spheres made of silica or alumina gel. The mass of these spheres in the reactor are kept constantly agitated by the incoming stream of oil vapour —this is the 'boiling' or 'fluidised' bed. The 'spent catalyst standpipe' is continually tapping a fraction of the spheres, which go to the regenerator where their carbon coating is burnt off. Escape of any spheres carried up in the flue gases is prevented by a cyclone (not shown).



such distinction.* The existence of vitamins had first been postulated by Gowland Hopkins in 1906, and their existence was proved and their nutritional importance established by that pioneer band of research workers which included Gowland Hopkins, Funk, Drummond and Mellanby in Britain, and Osborne, Mendel and McCollum in the United States. In 1925 a new 'break' in vitamin research came with the artificial production of a vitamin, which was achieved by the Medical Research Council team led by Bourdillon who showed that certain sterols, irradiated with ultra-violet light, were capable of curing rickets —in other words, the irradiation produced something possessing the same property as vitamin D. Since then nearly all the known vitamins have been isolated as pure chemicals, and have been synthesised in the laboratory; the outstanding names in the progress of vitamin synthesis include A. R. Todd of Cambridge and Sir Ian Heilbron, formerly of the Imperial College of Science and Technology in London, R. R. Williams and Folkers of the U.S.A., Kuhn of Germany and Karrer of Switzerland.

The discoveries made in the research laboratories have been exploited industrially, and concentrated vitamin preparations and pure vitamins have become articles of everyday commerce. By 1946 British factories, for instance, were producing three synthetic vitamins—nicotinic acid, vitamin C and vitamin B_1—worth altogether £240,000 a year; at the same time over 100,000 gallons of the vitamin-rich oils derived from cod- and halibut-livers were being marketed each year by British firms.

The rate of discovery of new vitamins has naturally shown a decline after so much intensive research, and with the exception of vitamin B_{12} the post-war period has witnessed no new vitamin discovery important enough to make the front page of a daily newspaper. One was therefore tempted to predict that the recent book by Leslie J. Harris entitled *Vitamins: A Digest of Current Knowledge* (Churchill, 1951, 244 pp.), which is the most convenient and generally comprehensive summary of the key facts about vitamins available, is not likely to grow out of date very rapidly.

Yet within the past six weeks there appeared a research paper in the columns of the *British Medical Journal* (June 28, 1952; No. 4773, pp. 1384–5) which suggests that the existence in liver of a new vitamin or a new growth factor must be postulated to explain the results of a set of feeding experiments carried out by Prof. John Yudkin, professor of physiology at King's College of Household and Social Science, London University.

Last year Prof. Yudkin and his colleague, B. P. Wiesner, found that when rats were fed on a standard diet, which according to current dietetic knowledge should have satisfied all the animals' nutritional requirements, their growth was further improved by giving them a small supplement of liver. This effect was produced by both fresh liver and a specially prepared liver powder.

Prof. Yudkin decided to try the same experiment with children. For this purpose, dried beef liver was incorporated into bars of orange-flavoured chocolate, each bar (weighing $\frac{3}{4}$ ounce, or 20 grams) containing 2 grams of liver powder. For his control tests Prof. Yudkin used chocolate bars of the same size and flavour, but containing no liver powder.

The children who took part in his tests were from four London day nurseries, and were all between two and three years old. In all, there were 75 children—40 boys and 35 girls. In height and weight they were all up to standard; in both respects they were on the average slightly, though not significantly, above the average figures for London children. In each nursery, half the children each received one bar a day of the 'fortified' chocolate, and the other half were given an 'unfortified' bar. This meant that every child in the first group took 2 grams of dried liver on every school day, or the equivalent of 12 grams of fresh liver.

The experiment continued for 13 weeks. At the end of that time the children who received the liver supplement gained on average about $\frac{1}{4}$ in. more in height and 10 oz. more in weight than the children in the control group. These gains were roughly 20% and 40% more than those of the control children. Prof. Yudkin gives his reasons for discounting the possibility that the increased growth might be due to the effect of vitamin B_{12} present in the liver supplement, and if his argument in this direction is proved valid by further experiments the existence of a new vitamin or growth factor must be assumed. But further experiments do seem to be required to establish its existence.

Progress Report on Two Agricultural Discoveries

Two agricultural discoveries about which we keep on being asked for further information are the new soil-conditioner called Krilium, and the 'boom-food' effect produced by the antibiotic aureomycin when added to the stock feed of pigs, chickens, etc. (DISCOVERY carried a "Progress of Science" note about the first in February 1952, and Chapman Pincher's article about the aureomycin story was published in December 1951.)

Krilium, it is announced by the London headquarters of the Monsanto Chemicals Ltd., is to be produced in Britain, at their Newport factory. Initial production will be on a semi-commercial scale. To start with, the first supplies of Krilium available here are being released to British agricultural research stations; the initial field trials will be on a fairly large scale, something like a hundred acres of land being devoted to these tests of Krilium. This soil-conditioner is now on sale to the public in the United States, but no decision has been reached as to when it will be made generally available this side of the Atlantic.

Another important soil-conditioner is now on the American market. This is called Aerotil, made by the American Cyanamid Co. This is available in two forms, flake and powder. The flake form of Aerotil dissolves readily in water and contains a higher concentration (83%) of active ingredient (a hydrolysed polyacrylonitrile) than any other soil-conditioner now available. A pound of flaked Aerotil mixed with 16 gallons of water is enough to treat 200 square feet of ground, and in this form is suitable for garden use. Aerotil powder, on the other hand, is better adapted to farm use; this contains 40% of the active

* The key experiments which established the reality of the vitamin concept were described in *Journal of Physiology* by Gowland Hopkins in 1912 (see Vol. 44 of that journal, p. 425). In those experiments, he fed a synthetic diet to rats which developed a 'deficiency disease' and this he cured by adding a minute amount of fresh milk to their rations.

ingredient, and other materials are present which make it easier to mix uniformly throughout the soil; it is applied evenly at the rate of one pound for every 100 square feet of soil and is then raked in to a depth of not more than ½ inch. (To improve the soil to a greater depth, more conditioner has to be used.) Like Krilium, Aerotil renders caked, eroded soil porous and granular and less liable to crust or bake at the surface; water absorption and retention by the soil is increased and erosion limited. As a result of these effects, the soil is more friable and can be worked more promptly after a rain. The improved loose soil condition is retained, even under the force of severe rains.

* * * * *

The claims of the American research workers with regard to the beneficial effects of antibiotic when added to pig meal were that:

1. It increases the growth-rate of normal pigs so that they can be reared to market weight several weeks in advance of the usual time;
2. It brings about an enhanced utilisation of feeding-stuffs, the pigs eating substantially less per pound gain in weight;
3. It stimulates the growth of runts, the dwarfed, unthrifty pigs which occur in many litters and never reach marketable size.

The first two claims are now being thoroughly investigated in Britain by the Agricultural Research Council. Preliminary results indicate that the claims are justified, but that the gains will not be so spectacular under British conditions. American pigs are fed chiefly on maize and do not normally thrive so well as British pigs which get more animal protein.

The third effect, however—the stimulation of the growth of runts—should have important applications everywhere, according to a current research report published in *Veterinary Record* (June 21, 1952; Vol. 64, p. 365). During the past year many cases of bad thriving leading to severe emaciation and death have occurred among pigs in northern Scotland. A typical litter of this type shows one or two very good pigs, six or more moderate pigs and one or two runts. Many lines of treatment have been tried, including dosing with sulpha drugs, but without result. So Mr. P. L. Shanks, a veterinary surgeon of Bucksburn, Aberdeenshire, staged feeding trials of the aureomycin supplement on three farms. 'Aurofac', a proprietary powder made from residues left after aureomycin has been extracted from the mould *Streptomyces aureofaciens*, was given at a rate of ½% of the meal to five runts. Five normal pigs of the same age—22 weeks—served as controls. They were given the same food without the antibiotic.

During the first fortnight the runts gained more weight than the controls, an astonishing result since they would otherwise have lost weight. During the test, which lasted eight weeks, the runts made an average daily gain of 1·12 lb. using 3·2 lb. of food for each pound of live-weight, whilst the controls gained 1·04 lb. daily using 4·4 lb. of food in the process.

The trials on the two other farms which involved twelve more runts produced similar results.

Quantities of material from which the growth stimulant could be made are being stored at the South Wales factory where aureomycin is extracted.

The Government will not sanction its use in Britain in National pig meals until the Agricultural Research Council trials are complete.

Stereoscopic Films

THE reopening of the Riverside Theatre of the Festival Gardens at Battersea with a programme of new three-dimensional films is a good occasion to examine the present state of stereoscopic films in general, especially as there are rumours that more elaborate stereoscopic films are due to reach British cinemas in the near future.

The third dimension was bound to come to films sooner or later, just as the addition of sound-track was inevitable—in fact stereoscopy 'came' successfully in 1934 when the film known as 'Audioscopiks', working on the anaglyph system, was shown in the U.S.A., and a year later in this country. Indeed, Friese-Greene was experimenting with three-dimensional films as early as 1890; the stereoscopic moving picture then seemed as desirable and inevitable an improvement to be sought as the stereoscopic still photographs which the Victorian age enjoyed through their stereoscopes one hundred years ago, not so long after the invention of photography itself. (The principles of stereoscopic vision were understood long before that, of course.) But just how far have stereoscopic films advanced since then?

Judged as pure entertainment, these latest films at Battersea are disappointing—as were last year's at the Telekinema in the South Bank Exhibition. The most obvious appeal of the illusion of three dimensions is the 'stunt'—the ability apparently to dangle something just in front of the audience's nose, or make things appear to move violently towards, or away from the audience. These latest films do not succeed in this, the crudest trick of stereoscopy, whereas the 1934 'Audioscopiks' used to have the audience in shrieks, and so, too, does the old music-hall stunt of back-projecting red and green pairs of images on to a white sheet on the stage—the illusion of depth here is terrific. These modern films draw only an occasional titter or slight gasp from the audience.

Perhaps there is a conscious desire in the making of the new films shown at Battersea to 'play down' the sensational or 'stunt' aspect. If this was the case, it has been overdone; the films are not nearly impressive enough. Both in style and in choice of subject, the 1951 and 1952 films—the former of which are now being shown commercially in cinemas in this country, Germany, Holland and Belgium—are rather lacking in imagination. They show little effort to make creative use of the third dimension; the powerful effect of prominent foreground objects is very seldom used to advantage, and hardly anything 'stands out' very far into the auditorium. There is often less actual sensation of depth than in the old-fashioned stereoscope, in which a good stereo pair, correctly mounted, could produce the most striking illusion.

Technically, any system for creating the illusion of three dimensions by means of images in only two dimensions must depend on causing the left eye of every member of the

audience to see a slightly different picture from the right eye—just as would happen if real solid objects were there in place of the flat screen. So whatever system of actually viewing these images is used, two sets of images—the 'left-eye' and 'right-eye' views must first of all be *photographed*, and these two sets of images must then be separately *projected*. The type of camera(s) and projector(s) will not in general be affected by the viewing system adopted. Thus a single camera with optical beam-splitting device and the two sets of images side by side on one single strip of film may be used, or twin cameras with twin strips of film; and a single projector with similar beam-splitter or two interlocked projectors. Basically, all this does not affect the viewing system, provided that the fundamental requirements are met: that two viewpoints of the object are photographed, corresponding to the positions of the left and right eyes; and that these two sets of images are separately projected on to a common screen in such a way that they can be separated out again from eye to eye. This separation must now be done, and here a viewing system must be devised to do the sorting-out for each member of the audience.

Now there are only two practical places at which this can be done: at the screen itself, by some system common to *all* viewers, or *individually* at the eyes of each viewer—that is, with spectacles. In DISCOVERY for November 1949, a practical system for doing the former was described—the Russian grid, or raster, system invented by S. P. Ivanov. Two special cinemas in Moscow were equipped some years ago with this system, and their success does seem to indicate that it is one very successful solution of the problem.

Only the second method, in which every member of the audience must wear spectacles, has so far been seen publicly in this country. The separation of the images on the screen into left-eye and right-eye has been done in two ways; by using colour, and by polarised light. In the system using colour, known as the anaglyph method, one eyepiece of the spectacles consists of a piece of red glass or gelatin, and the other of green-blue; the left- and right-eye pictures are projected on to the screen through filters of the corresponding colours. This method gives good results but is apt to cause eye-strain (or brain-strain?) due to the fact that one eye is receiving an overall red impression and the other an overall green-blue one. This disadvantage is overcome by the second system in which the eyepieces are neutral-tinted Polaroid filters with their planes of polarisation at right angles to each other, the two projected images being similarly polarised by filters on the projectors. Thus either black-and-white or colour films can be shown by the Polaroid system. A colour film made on this system, showing the assembly of a Chrysler car, was shown at the New York World's Fair in 1939; and this is the system used at the Telekinema last year and at the Riverside Theatre and elsewhere at present.

An invention which excited considerable comment in America a year ago and will, it is believed, shortly be seen in this country, uses a huge curved screen of the diorama type. It is claimed that this system produces an illusion of depth in the third dimension, which is enhanced by multiple sound tracks (which were, incidentally, also used in the Telekinema). But to judge from the published description of this system, whatever illusion of depth may be induced by the size and curvature of the screen and by the fact that the eye cannot take it all in at once so that images are caught by the corner of the eye, it certainly is not true stereoscopy, in that *both* eyes must apparently receive *identical* images of whatever is in front of them on the screen.

There are rumours that a system similar in principle to the Russian one—that is, based on a grid or raster in front of the screens—will sooner or later make its appearance in this country. Till then we will have to be content with looking at stereoscopic films through spectacles—and judging by audiences' reaction at the Telekinema and the Riverside Theatre, there is not nearly such prejudice against spectacles as protagonists of the raster system like to suggest—and to hope for more imaginative films.

Bacteria 34,000 Feet Below Sea-level

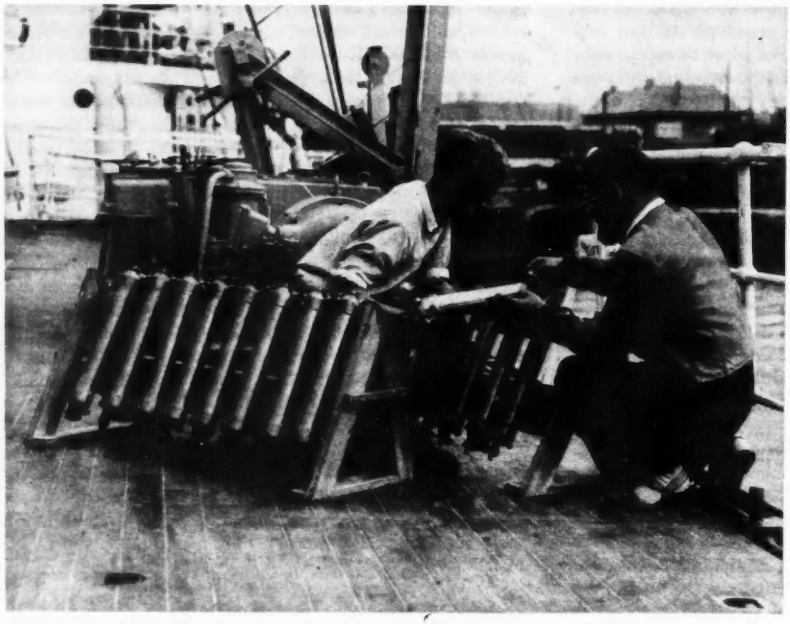
THE latest deep-sea expedition has now returned to base—the Danish expedition in the frigate *Galathea*, which has travelled the oceans establishing new records for deep dredge hauls. The expedition, whose scientific director was Dr. Anton Bruun of Copenhagen University, spent nearly two years at sea.

Recently the British survey ship *Challenger* set up a new record with a depth sounding for 5960 fathoms (10,900 metres), the measurement being based on an ultrasonic echo-sounder reading so that a correction reducing that figure by 20 fathoms was considered necessary by hydrographic experts. This spot, where the ocean bed is at least 5940 fathoms (10,863 metres) below sea-level, is the deepest point of the Mariana Trench, some 200 miles to the south-west of Guam.* Depths of a similar order have been recorded from the Philippine Trench, which is a rift in the sea-bed off the Philippine Islands, and it was this region which Dr. Bruun's team worked over with various sampling devices, and which yielded specimens of abyssal life from depths of 34,000 feet. The expedition had gone to the Philippine Trench because at that time the deepest soundings had been obtained in that region. It was actually while the *Galathea* was in this neighbourhood that the *Challenger* established the even greater depths in the Mariana Trench, but as Dr. Bruun has said the *Galathea* did set up a new record for deep fishing at the same time as the *Challenger* was breaking the very depth-sounding records which had led the *Galathea* to the Philippine Trench.

The most remarkable discovery to be made by the *Galathea* was that bacteria exist in mud obtained from the sea-bed 34,000 feet below sea-level. This extends considerably the range of the curious deep-sea bacteria first described by Dr. Claude E. Zobell, the scientist of the Scripps Institution of Oceanography in California who has made marine microbiology his speciality.

The first reports of the existence of these deep-sea bacteria were published over 18 months ago after Dr. Zobell had found them in samples of the sea-bed collected from depths up to 15,000 feet by the deep-sea expedition sent out in 1950 by the Scripps Institution and the U.S. Navy Electronics Laboratory. The bacteria proved to be

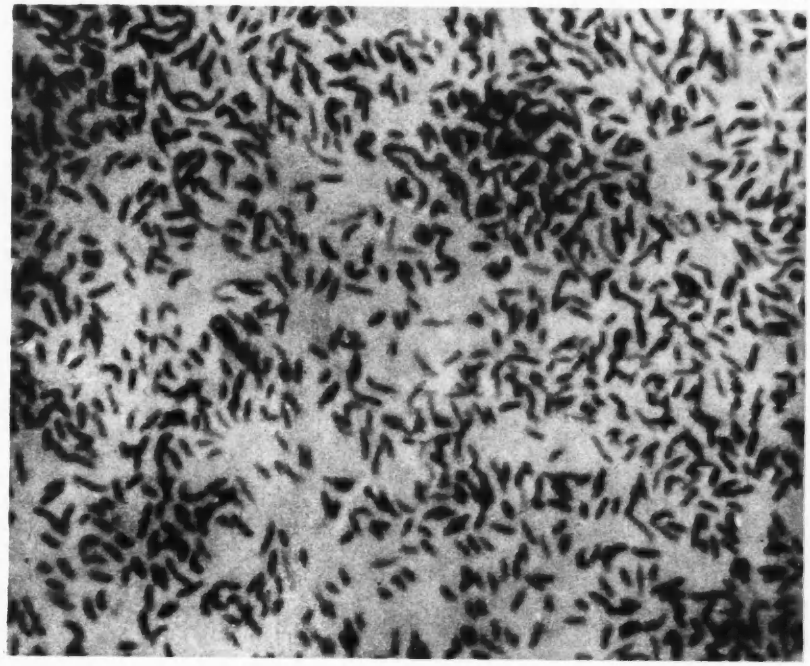
* Details of this record depth sounding can be found in *Nature*, April 1952, p. 601.



(*Top left*)—Dr. Claude E. Zobell, U.S. specialist on marine microbiology, is seen holding a special steel culture vessel he devised in order to be able to grow in the laboratory deep-sea bacteria under the high hydrostatic pressures they meet in nature.

(*Above*)—Many of Dr. Zobell's bacteria come from cores taken from the sea-bed by means of the piston core sampler (described in DISCOVERY, Nov. 1948, and here seen being demonstrated by its inventor, Dr. B. Kullenberg).

(*Left*)—Other specimens of deep-sea bacteria have been collected in the steel bottles normally used for taking sea-water samples at great depths.



DEEP-SEA BACTERIA

This photomicrograph was one of the first taken in Dr. Zobell's laboratory after his discovery of bacteria in sea-bed samples collected at 15,000 ft. Deep-sea bacteria are usually coloured, being orange, red or brown.

full of life, and multiplied rapidly in Dr. Zobell's laboratory. Which meant that this scientist was handling living organisms which had been subjected to a temperature near freezing point and pressures of the order of 7500 pounds per square inch—for those are the conditions at 15,000 feet below sea-level—and still survived. According to Dr. Zobell, these bacteria differ in shape, structure and physiology from all other bacteria. One puzzle they present is, what do they feed on? Is there likely to be sufficient decaying organic matter, in the way of the decomposing bodies of planktonic organisms which sink down from above, to nourish them, or have they some biochemical knack of changing inorganic materials into organic matter? Points like these will be settled only after a great deal more research has been put into their physiological processes. It now emerges from the findings of the *Galathea* expedition that deep-sea bacteria are even more remarkable than they appeared to be when first examined; for they can apparently stand a pressure of a thousand atmospheres.

"The Coming of Heredity"

THE article entitled "The Coming of Heredity", which appeared in the May issue of DISCOVERY, was based on a B.B.C. talk by Dr. Darlington. Conversion of this radio script into article form necessitated some modification, which is customary in the magazine field when scripts prepared for broadcast presentation do not lend themselves to verbatim reproduction in print. By a misunderstanding at proof stage a passage found its way into print which Dr. Darlington considers to be an unfair rendering of the concluding remarks he made over the air. We offer our apologies to Dr. Darlington for this unfortunate mishap, and we print below the concluding paragraph of the talk as it appeared in *The Listener* of January 3, 1952, to be read in substitution for the last two italicised paragraphs which appeared on p. 143 of our May issue.

". . . *But we must remember that the total capacity for prediction in both branches of science is continually increasing. This is the inside of the question. The outside is made of more practical matters. The consequence of this determination, and of our expanding knowledge of how it works, is that the expectation of 100 years ago, the expectations of Darwin and Huxley and Galton, can now be brought to fruition. Now we can interpret the structure of human society, the problems of education, and the practice of medicine, in terms of biological principles. Now we can attempt to understand the history, and look forward to the future, of the human race equipped with the immense resources of experimental method. Now we can bring together all the disconnected elements of social science. In a word, we can learn to understand mankind. The understanding that we get is indeed revolutionary. These ideas are much newer, much more recent, than the great opinions which at present divide mankind, the catholic, the liberal, and the marxist views of life. And they challenge them all. We must therefore expect them to be disputed, even more tenaciously, even more fiercely, than the correspondingly disputed theory of the last century, the theory of evolution.*"

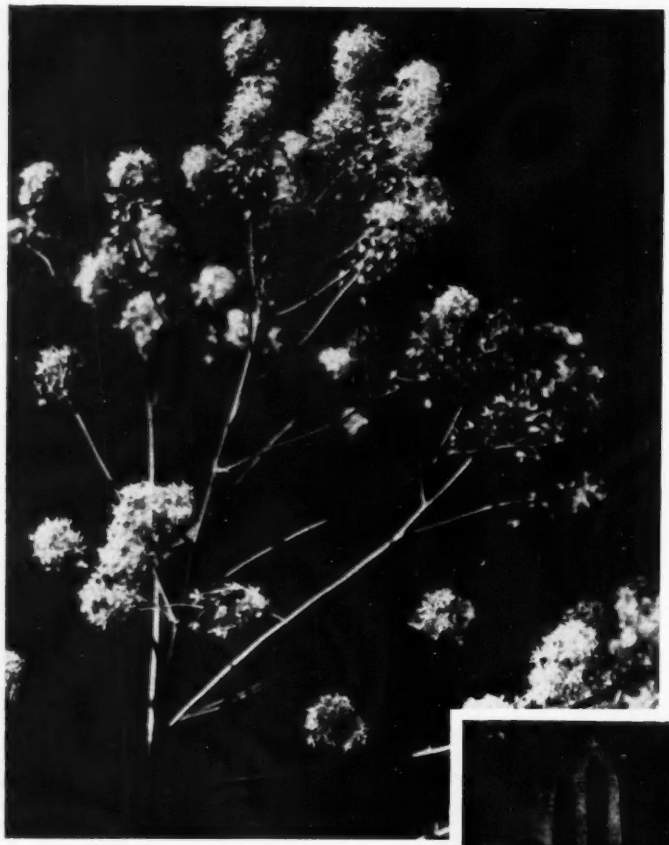


FIG. 1.—Woad flowers (bright yellow) on plant grown by Rex Wailes in 1943. Second-year growth, 6 feet high.
Courtesy Kodak, Ltd.

FIG. 2.—Fifteenth-century dye vat, from early manuscript.
Courtesy British Museum

From Woad to Indigo

ALEXANDER BARCLAY, F.R.I.C.

WOAD is a substance which has been used from time immemorial for producing a fast blue dye like indigo. Centuries ago our ancestors are recorded to have stained their bodies with it, and in medieval times it was manufactured on a very large scale on the Continent. In our schooldays we first gain an impression of the early Britons as a primitive and warlike people bedaubed with blue, and though we may disbelieve the story it is nevertheless supported by classical references.

Caesar describes the wild appearance of the Britons in battle due to the blue colour of woad (*vitrum*), and Pliny the Elder tells us of a plant called *glastum* in Gaul which was used by the womenfolk in certain religious ceremonies to stain their bodies to a swarthy hue. Herodian is more precise. He alludes to the figures of animals with which the ancients decorated themselves. Thus we find that the use of woad was well established among our forebears, though it is not clear how they obtained their supplies. The woad plant was not native to Britain. It came probably from south-eastern Europe, whence by cultivation it spread west to France and north as far as Scandinavia. According to Corder there appears to be no real evidence of its cultivation in this country before the thirteenth century.

It may be that the ancient Britons obtained their woad from the Gauls in the form of a fermented dye product, in which case they could have used it as a tattoo by puncturing the skin. If fresh woad leaves had been obtainable they would have produced an indelible, almost black, stain by rubbing the juice on the skin. This effect was common in England in recent times when the hands of the wadmen (woad-men) of Lincolnshire and Cambridgeshire became blackened during work, returning to their normal colour only with the growth of new skin.

At this point we may inquire what exactly is meant when we speak of woad. The plant itself is known as *Isatis tinctoria*, or Dyer's Isatis. It is a biennial with lance-shaped leaves, a little reminiscent of those of spinach but growing much taller, and producing showy clusters of bright yellow flowers, somewhat like those of mustard,* in its second year (Fig. 1). The blue dye obtained from the woad plant is known chemically as indigotin, or indigo blue, so called because it is common also to the indigo plant, *Indigofera tinctoria*. The dye is not, however, contained in these plants as such, but is present in the form of a yellow, or a colourless, substance which can be extracted and converted into the dye by suitable treatment. In the woad plant it is believed to consist of a compound resembling indoxylic acid, which can be converted by fermentation into a yellowish substance known as indoxyl. This substance in solution is rapidly changed by atmospheric oxidation into indigo blue, which separates as an insoluble scum on the surface of the liquid. If cloth or yarn is steeped in an indoxyl solution, which is of a brownish-yellow colour, it will turn blue when hung out in the open air. Azure-blue shades are first obtained, becoming darker with every subsequent immersion.

In the indigo plant, on the other hand, the dye principle is present as the compound indican, a glucoside which can be split up, or hydrolysed, by fermentation into indoxyl and the sugar, dextrose. Briefly, the Indian process consisted of steeping and fermenting the plant in warm water to obtain an indoxyl solution. This was then aerated by beating with laths to precipitate indigo blue by oxidation. The dried product was marketed in the form of blue cubes which, however, had the disadvantage of being completely insoluble in ordinary solvents. To obtain satisfactory solutions for dyeing purposes it was necessary to employ a somewhat circuitous process, whereby the insoluble dyestuff was converted into a colourless compound known as indigo white. This is readily soluble in dilute alkalies and on exposure to the oxygen of the air is reconverted into insoluble indigo blue.

This is the principle of vat dyeing, so called from the fact that a special kind of dye bath is prepared by a process of reducing an insoluble dyestuff to a soluble intermediary (Fig. 2). The material to be dyed is simply immersed in the reduced indigo vat and exposed to the air, when the insoluble dye is precipitated on the fibre. The conversion to a soluble form can be accomplished by fermentation and for a long time woad was the only known material for this purpose. Hence the term 'woad vat' or 'fermentation vat' as distinct, for example, from a zinc or hydrosulphite vat in which one or other of these substances is used as the reducing agent.

The Blue-coat School

Various other materials were added to a woad vat, such as bran, for its use in promoting fermentation, and madder-root, also a fermentable product, but possibly added from a mistaken idea of its efficacy in counteracting a greenish tinge, which was liable to appear as a result of using an indigo-woad vat. Lime was used to regulate fermentation by neutralising acids and to furnish the alkali necessary for the solution of the reduced indigo. Indigo-woad vats were in use up to recent times, and when once started they could be kept going for weeks on end with careful manipulation. Although the vats were cumbersome and critical in operation the results obtained were not surpassed for the exceptional fastness to sun, rain and sea-water imparted to cloth or yarn dyed in this manner. Woaded cloth was, in fact, so highly regarded that the term was used later for any indigo-dyed cloth, whether or not woad was used. Seamen's garments, police uniforms, and the well-known gowns of Christ's Hospital, or 'blue-coat', boys were all dyed with woad until superseded by indigo.

In medieval times woad cultivation and dyeing attained considerable importance on the Continent, where a flourishing trade was carried on over a large part of Germany, particularly in the district around Erfurt in Thuringia. A valuable work by Schreber, published in

* Woad belongs to the same family (Cruciferae) as mustard, cabbage, radish, wallflower, etc.

1752, recorded all that was then known on the subject of woad cultivation and manufacture, and it included an interesting woodcut of a German woad mill (Fig. 3). In essence, the process consisted of crushing the young woad leaves under a horse-drawn roller and compressing the resulting pulp by hand into balls which were laid out on racks to dry. After a few weeks these balls were ground into powder and fermented by spreading upon a barn floor to a depth of two or three feet. Water was sprinkled over the mass and the temperature was carefully controlled by frequent turning. The object of fermentation, or couching as it was called, was to destroy certain useless organic constituents of the woad plant and to concentrate the essential dye principle in a form of use to the dyer. Stringent regulations were in force to govern the activities of the woad-ball merchants and of the couchers, or woad refiners, neither of whom was allowed to infringe on the work of the other. Trade guilds were formed in all leading woad centres, and in Germany the manufacture of woad became so important that most towns in which dyeing was practised were provided with a 'woad-hall' in which the finished dyestuff was stored and assayed.

Woad was also cultivated in many districts of Italy. In Tuscany we find that powerful woad guilds were established in association with the important Florentine wool and cloth industry. According to Hurry, the guilds of Florence supply the most remarkable example of industrial organisation known in the Middle Ages. In France also there were important woad centres in Picardy, Normandy and Upper Languedoc. The method of preparation differed somewhat from the German and English processes. After crushing the leaves in a mill, the pulp was thrown into a heap which was trodden and beaten at intervals for two or three weeks until a stiff paste was formed. This was converted by means of moulds into balls or cakes called *cocaignes* which were broken up at a later stage and fermented in much the same way as in other countries. The wealth of the 'pays de cocaignes' round Toulouse became proverbial.

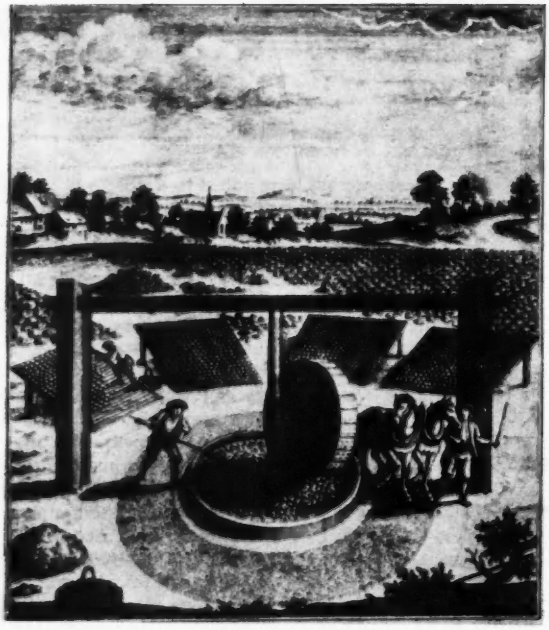


FIG. 3.—German woad mill, after D. G. Schreber, *c.* 1750. Note the large roller for crushing the leaves, and also the racks for drying the balls prepared from the crushed leaves.
By Courtesy of the Science Museum, London

Woad was extensively cultivated in England during the Middle Ages, particularly in the fen-lands around Boston in Lincolnshire and Wisbech in Cambridgeshire. In Somerset also there was a noted centre at Glastonbury which probably derived its name from *glastum*, the Roman synonym for woad. The scale on which woad dyeing was carried on at that time can be gauged by the fact that large quantities of fermented woad or *pastel* were imported from France in addition to the material made at home. Agreements are in existence which refer to the export of woad by the merchants of Amiens and Corbie to Norwich in 1286, and to London in 1334.

The methods of preparation in England remained almost unaltered from the fourteenth century, and it is fortunate that detailed records of the last remaining woad mills were made before the industry became extinct. The plant required a rich soil, preferably fresh pasture land on an alluvial saline site. High prices were often paid for the best land which was rapidly exhausted by woad cultivation. In consequence, it was the practice to move every three or four years to a fresh site, and in this is to be found the origin of the typical movable woad mill which was dismantled and re-erected as required. To this practice also can be traced the travelling bands of agricultural workers known as 'wad-men', from the Saxon 'wad', who accompanied the mill from place to place and whose skill and knowledge was handed down from father to son.

Woad cultivation required much care, and during growth the plant was carefully weeded by hand, using a curious instrument known as a woad-spud. The young woad leaves were cropped two or three times during the first year and were taken without delay to the mill for crushing. Only first-year leaves were of value, older leaves containing little, if any, dyestuff.

The last of the movable woad mills in this country was situated at Parson Drove, near Wisbech, where it remained until dismantled in 1914. A painting which has recently come to light clearly shows the three tapered rollers used for crushing the leaves (Fig. 4). Each roller was drawn by a horse which traversed a circular track inside a thatched shed of rough construction. The rollers consisted originally of stone, but were made later of heavy wooden hubs shod with iron bars, of which there were about forty to each roller (Fig. 5). After draining away the juice, the pulped mass was kneaded by hand into balls about 6 in. diameter against a flat wooden board known as a balling horse. The balls were taken to drying ranges consisting of open wooden structures containing tiers of hurdles known as fleaks, where they were left to dry for three to four weeks.

At the end of this time followed the most important and difficult part of the process, known as couching. The balls were broken up in the mill and the powder was spread out on the stone floor of a darkened barn or shed to a depth of about two or three feet. The shed adjoined the mill and was

FIG. 4.—Woad leaves being arranged for crushing at Parson Drove Woad Mill. An oil painting by J. Doyle Penrose, *c.* 1906. *Courtesy Wisbech Museum*

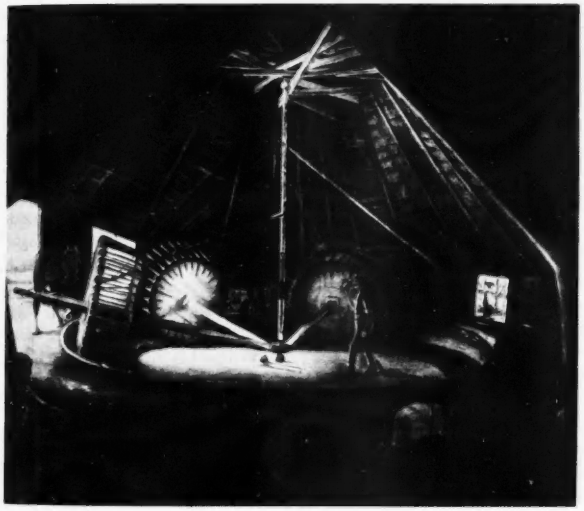


FIG. 5.—Interior of Parson Drove Woad Mill, near Wisbech, showing horse-drawn rollers for crushing leaves. An oil painting by Alfred Balding, 1900. *Courtesy of Mrs. C. C. Titchmarsh and Science Museum*

FIG. 6.—General view of Parson Drove Woad Mill; the photo was taken about 1900, when the mill had been disused for some time. Drying ranges for woad balls on left. *Courtesy Wisbech Museum*

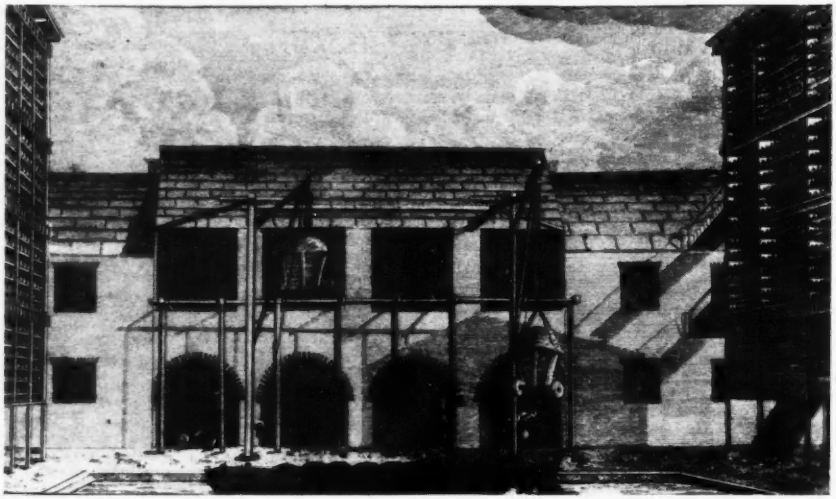


FIG. 7.—Brothertoft Woad Mill near Boston, Lincs., about 1800. *Courtesy Science Museum*

known as the couching barn. Here the mass was sprinkled with water and allowed to ferment for about eight weeks, during which time the temperature was carefully controlled by frequent turning in order to obtain a satisfactory product. The result was a damp, brown, clay-like mass which was rammed tightly into large sugar barrels and sent to the dyers. Prepared woad had a strong ammoniacal odour and gave a yellowish-brown solution in water. The smell of fermenting woad was in fact so unpleasant and penetrating that Queen Elizabeth prohibited the process of couching within some miles of her presence.

Woad was long used alone for producing blue shades, but after the introduction of natural indigo in the sixteenth century it was gradually superseded by the indigo-woad vat, in which woad was used merely as a convenient source of ferment. Indigo leaves contained a much higher proportion of dye principle than the woad plant and their extraction was more readily accomplished. To protect the woad trade from this competition a law was passed in Elizabeth's reign, prohibiting indigo as a dangerous drug and authorising searchers to burn it wherever found. This law remained in force until about the middle of the seventeenth century.

The use of woad as a ferment persisted until quite recent times. Several steam-driven mills were erected in Lincolnshire, and in 1800 we come across a remarkable instance of mass production of woad in England. To obviate the necessity for moving to new pastures as the land became exhausted, a Mr. Cartwright of Brothertoft conceived the idea of utilising a tract of land sufficiently large to allow a rotation of crops, with enough woad under cultivation at one time to keep the mills in regular operation. To this end crops of woad, oats, cole and grasses were sown in a certain order, and at the time of the original description (1799) the experiment was proving a success. About 980 acres were required to operate the method which allowed for the cropping of 200 acres of woad annually. The cropped leaves were taken to the mill in specially constructed carts of which the central portions were hoisted bodily up to a floor above the mill (Fig. 7). The contents were discharged vertically downwards through the bottom of the cart, which was composed of folding doors. The mill contained eight grinding wheels revolving over a granite track, and each wheel was driven by a relay of up to three horses, making twenty-four in all, so that work could go on continuously. As each batch of leaves was crushed the resulting mass was thrown with shovels into adjoining rooms and fresh leaves were introduced to keep the mill going. A series of eight large drying ranges was provided, and ample storage space for the dried balls was available above the mill. When field operations were at an end the balls were ground and fermented in the manner already described, but very careful precautions were taken to obtain the best results.

In 1800 the total output of woad in England did not exceed fifty tons per annum and by the end of the century it had dwindled to a negligible quantity. The industry was largely a primitive one and the movable mills were roughly built. The roofs were thatched and the walls were made of turf blocks arranged in a herring-bone pattern. Many quaint customs and terms survived among the wadmen. "As blue as wad" was a common saying in East Anglia down to recent times, and it was not unusual for a wadman to have been "cradled in the wad", a reference to the practice of the women of leaving their babies in baskets in the fields while they plucked the woad leaves in summer.

It is a constant surprise to find that ancient industries and crafts, long thought to be extinct, have survived for centuries, and it is fortunate that in most cases sufficient records are to be found from which their history can be reconstructed in some detail.

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No one is better qualified to assess the value of Baird's contribution to television than Mr. Parr, Secretary of the Television Society, who gained an intimate knowledge of the details of T.V. development through his editorship of "Electronic Engineering" during a key period in television progress.

The Story of Baird and Television

G. PARR, M.I.E.E.

In the autumn of 1951 the London County Council erected a plaque on the wall of 22 Frith Street, Soho, marking the house where the television of living images was first demonstrated by John Logie Baird in 1926. This year, the Bexhill-on-Sea Corporation has erected a tablet on the house in Station Road where he spent the last years of his life, and his birthplace in Helensburgh is to be similarly commemorated.

The erection of these memorials to a man who, in the opinion of many, was merely an ingenious experimenter, and not so very ingenious at that, has tended to revive a controversy which has always been associated with the name of Baird.

At the recent Television Convention one speaker openly expressed his disapproval of such tributes—a singular comment to an audience gathered to hear about the British contribution to television. For the fact remains that the first public television service in the world was by the Baird system, broadcast by the B.B.C., and it was he who established the first television transmitter (2TV) in Long Acre in 1928 at a time when other countries were waking up to the possibilities of this new science.

In the few years between his first demonstration and the first public transmission, Baird had shown all the aspects of television that are well known today: outside broadcasting, large screen pictures, colour, and even stereoscopy. Very few modern viewers remember that the first outside broadcast took place in 1931, when the Derby was televised—an event of historic importance, even though the horses could hardly be distinguished from humans except by the number of legs.

With all this pioneer work to his credit, what has prevented Baird from being acclaimed as Marconi has been acclaimed? Marconi did not invent radio any more than Baird invented television. In some ways his early work and experiences were similar to Baird's. The foundations had been laid for him by earlier workers, although, like Baird, he filed patents of his own. His early apparatus was crude, and he had little more than faith in the future when he arrived in this country. Baird had immense faith in the future when he set up in London. But where Marconi found an enthusiastic supporter in Sir William Preece with the authority of the Post Office behind him, Baird had no such support in his early days, and this was to prove a more powerful handicap than he ever considered.

The cause of the reluctance to hail him as a great inventor, worthy to rank with Marconi, is to be found partly in the circumstances of his early work, partly in his early associates, and partly in the man himself. In trying to judge the influence of these factors we are helped by the recent book written by Mr. Sydney Moseley,* who was his intimate friend and who had access to Baird's autobiography—which would have been published but for the restrictions of the last war.

Baird was not a scientist in the accepted sense. He had electrical experience and had been technically trained at Glasgow Technical College, where he was a contemporary of John Reith (now Lord Reith). It is significant that at the first meeting with Reith, Baird was "overawed by his height, his apparently lofty social standing, and his superb air of self-confidence". Many a stronger character experienced the same feeling when dealing with the Director-General of the B.B.C. in his official capacity.

After various unsuccessful attempts to make a living, Baird went to Hastings in the summer of 1923 to recover his health, which was never strong from his youthful days. (In later years he remarked to the writer that he might have been a different man if he had been free from catarrh.) It was in Hastings that he decided to pursue in earnest the schemes that he had read about previously for sending pictures by wireless.

There is no doubt that he owed his inspiration to the accounts of Shelford Bidwell, who first suggested the use of a selenium cell to convert light into electrical impulses, and by Rosing, Nipkow and others who had proposed a system of scanning. The first of Baird's experiments was a practical realisation of the Nipkow scheme, using a cardboard disc with spirally arranged holes as in Nipkow's patent of 1884.

He was confident, however, that by making use of the modern achievements in radio—the photo-cell, the thermionic amplifier—he could produce a workable television system.

His first apparatus was as crude as only lack of money and lack of facilities could make it. Nevertheless it worked, and Nipkow's scheme had never progressed beyond the drawing stage.

Encouraged by this, Baird inserted an advertisement in *The Times*, which should have attracted attention by its astute innocence:

> **Seeing by Wireless.** Inventor of apparatus wishes to hear from someone who will assist (not financially) in making working models.

A reply came from Mr. Odhams, of Odhams Press, but after taking technical advice Mr. Odhams declined an offer of a twenty per cent share in the invention for £100. Nevertheless, Baird benefited from the advertisement in being able to obtain some much-needed apparatus: "three DER valves, three LS.5 power valves, two intervalve transformers, and a 3-valve note magnifier".

Eventually, with help from Mr. Will Day and Mr. Selfridge (who staged the first demonstrations of television to the public in his Oxford Street store), Baird was enabled

* *John Baird* (Odhams Press, 1952, 256 pp. 16s.).

Sir Robert Renwick unveiling the plaque on the wall of 22 Frith Street, Soho, where Baird first demonstrated television in 1926.

J. L. Baird with his 'Telechrome' tube for colour television projection.

to come to London where he established himself at Frith Street and later in Long Acre. A generous sum of £500 from his cousins put his newly formed company, 'Television Limited', on a reasonably sound basis.

At this stage he was joined by a former business associate, Capt. O. G. Hutchinson, who, in spite of vigour and determination, was temperamentally incompatible with Baird. Nevertheless, with Hutchinson's aid, television was demonstrated to the members of the Royal Institution, as representing the scientific world, and to *The Times*, as representing the Press, the historic date being Friday, 27 January, 1926.

The pressing need was now money, and the co-operation of the B.B.C. Without money the company could not be developed, and without the B.B.C. it could never succeed. Hutchinson was able to interest Vowler & Co., whose partner, Col. Ian Anderson, was instrumental in launching a new company in 1928, Baird International Television, with a capital of £700,000. Both Baird and Hutchinson had shares in the new company, and when this was again subject to reorganisation, Baird was offered £125,000 for his shareholding, and a salary of £10,000 a year. It is an interesting sidelight on the outlook of the two associates that Hutchinson considered £125,000 totally inadequate for his shares and Baird declined the offer because he would not know what to do with the money. Mr. Moseley gives as his opinion that Baird was also guided in his refusal by the fear of losing control of the company and lived to regret his decision.

The financial deal was concluded only just in time, as on the following day the American Telegraph Co. in New York unexpectedly announced their own demonstration of television, and the monopoly which Baird had held for a year vanished.

An era of prosperity now began for Baird and his new company, and demonstrations were given all over the country including one at the British Association at Leeds. The lay press were acclaiming the latest marvel, while the technical press were sceptical.

It is here, in the writer's opinion, that Baird failed to establish himself in the eyes of those who could have done him service later. Convinced in his own mind that his system was good, he avoided technical discussion and made little attempt to enlist the support of many whose scientific reputations would have carried weight in the quarters where it was most needed. It was of little use reiterating in the Press that television was an accomplished fact and shutting one's eyes to its imperfections. Apart from the initial demonstration to the members of the Royal Institution, there is no record that he ever proposed to read a paper to any other scientific body or that he replied to the many well-informed opinions that were expressed on the future of his developments.

The next step was to enlist the help of the B.B.C. in putting over experimental programmes, and naturally he found their technical adviser 'cagey', to use the modern term. An approach to Sir John Reith had been unsuccessful, possibly due to the feeling of inferiority that Baird experienced, but also due to the previously expressed opinions of the B.B.C. technical staff.

Moseley, who had joined the Board of the Company and was a whole-hearted supporter of Baird Television, fought strongly on their behalf and succeeded in obtaining the agreement of the Postmaster-General to allow facilities for experimental transmissions by the B.B.C. These began in 1929 with vision only, and in 1930 both vision and sound were radiated on the two Home wavelengths. A landmark in these experimental transmissions was the first televised play *The Man with the Flower in his Mouth*, which was performed on July 14, 1930 with Val and John Gielgud as the actors, Lance Sieveking being the producer.

Two years later the B.B.C. installed a mirror-drum transmitter at Portland Place and regular 'professional' television was on the air.

One of the interesting questions that occur to the reader of these events is what use was made of the years of experimental transmissions which were undertaken for the purpose of improving the system. The standard of 30 lines, 12½ pictures per second had been determined at the inauguration of television, and Baird seems to have been content to allow this to continue without definite indication that it was no more than a beginning. He made various experiments in other directions, but in the meantime his rivals were developing their own systems with all the weight of their technical staffs behind the experimental work. It must be remembered that Baird was wedded to mechanical systems of scanning, in which he showed his ingenuity from the start, and it was partly his reluctance to realise that mechanical television had a very limited scope that led to his ultimate failure. For failure it was; by the end of 1930 the money had run out. The expected sale of television receivers proved quite inadequate to bring any return for the amount invested, and the necessary expenditure on publicity far exceeded the return in orders and equipment.

Television Ltd., the original parent company, had gone into voluntary liquidation, and the market value of the shares in Baird Television Ltd. had fallen to fourpence.

In his book, Mr. Moseley recounts the intricate and finally successful manœuvres which he made to obtain backing in America and London which finally resulted in the control passing into the hands of the Gaumont-British group.

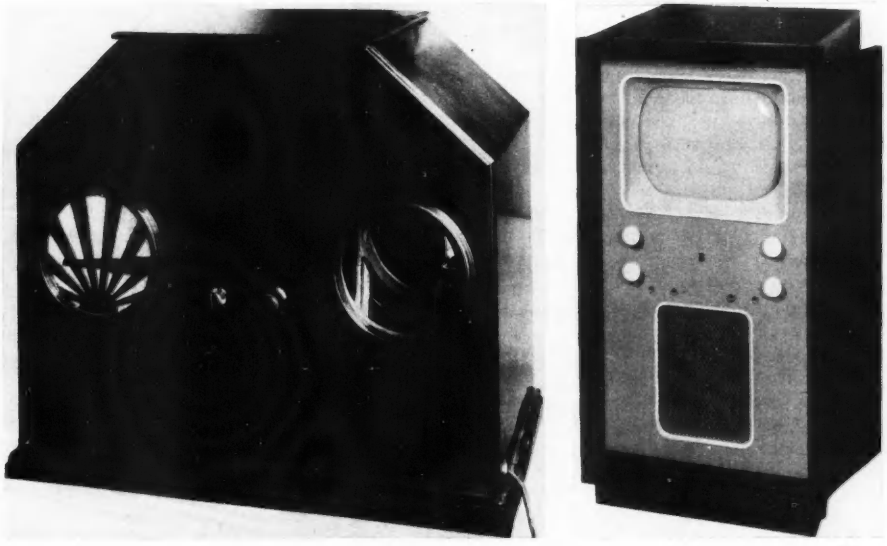
Quoting his words: "In London and provincial papers alike my name was bracketed with Ostrer's (the Chairman of Gaumont-British), and we were described as the two men who had saved television for Britain." "And so," adds Mr. Moseley, "for the time being it certainly appeared."

Baird at last began to see what lay ahead. The cathode-ray tube, which had arrived a few years after his first experiments, was the doom of the mechanical receiver, and the newly formed company began to develop electronic television. In 1933, another demonstration was given to the British Association of a 120-line picture on a cathode-ray tube, and the possibilities of short-wave transmission had already been explored.

But other firms were overtaking the Baird organisation, among them the powerful E.M.I. company in collaboration with Marconi's. The B.B.C. were offered two improved systems of high definition television, one by Baird of 240 lines, 25 pictures per second, and the other by Marconi-E.M.I. of 405 lines, 25 pictures per second interlaced scan. After a trial period of both systems in 1934, the interlaced system won the day, and with its victory went the final hope of the Baird Company to control British television. The war dealt Baird another blow, and although he continued his experimenting as best he could, he was handicapped by lack of funds and lack of outside interest. His inventive ability was turned to colour television, and he demonstrated a two-colour picture in 1941 made by superimposing two separate images from cathode-ray tubes on to one screen. This was dismissed in some quarters as impractical, but it is worth noting that the Radio Corporation of America developed a similar system later.

Baird died on June 14, 1946, a short while after the reopening of the B.B.C. television service. Of all the money that had circulated around his name and his projects, very little had come his way. Whatever his shortcomings in the technical sense, he was a man of whom no one spoke ill. Quiet, courteous and persistent, he went on the lines that he thought were right, and although others outstripped him in the quest for the perfect picture, he was the stimulus that set them on the quest.

It is therefore as the founder of television, not only in Britain but all over the world, that Baird deserves recognition, and a memorial plaque or two does not seem too elaborate a tribute to pay to one who ushered in one of the great social changes of our time.



(*Left*)—An early form of Baird television receiver, which was known in the 'trade' as "Jumbo". The loudspeaker is on the left, the television lens on the right. The receiver is about 36 inches across.

(*Right*)—A modern cathode-ray tube receiver.

Two Glass-blowing Monsters make 1,500,000 Bulbs a Day

A masterpiece of mechanisation is the new factory at Harworth, near Doncaster, which is capable of producing all the electric lamp bulbs required in Britain. The factory is built around two machines; between them, these twin glass-blowing machines can turn out no less than a million and a half lamp bulbs each day. The only other comparable machines that exist are in the U.S.A. The American machines are in fact operational prototypes of the two at Harworth, which incorporate improvements in design details suggested by experience gained in running the American prototypes.

This type of glass-blowing robot is called a Ribbon Machine. There were earlier automatic machines producing lamp bulbs: the first type to be made was called the Westlake Machine and it achieved an output of 3000 bulbs an hour, and this was followed by the Ohio Machine, with an output of 6500 an hour. The Ribbon Machine marks a revolutionary advance over both those types, and it can produce bulbs at a rate nearly seven times as great as the best Ohio Machine.

The Ribbon Machine swallows molten glass at one end, and at the other it spews out perfect electric lamp bulbs. By altering the size of the moulds which form a component part of the machine, it can be made to produce lamp bulbs of different sizes; this versatility also enables the machine to be used for the production of the glass envelopes of radio valves.

The operations involved can be understood with the aid of the diagram. A stream of molten glass flows down through a pair of rotating water-cooled rollers at the left-hand end of the machine. One roller has a smooth surface, whereas the other contains circular depressions; thus the glass which leaves the rollers is in the form of a continuous ribbon which bears a series of shallow circular protuberances—this ribbon reminds one, in effect, of the ribbon of 'caps' used in toy pistols.

The ribbon is carried along on a horizontal moving belt made up of units called orifice plates. Each orifice plate is pierced with a circular hole; everything is synchronised so that each hole comes accurately into position beneath a 'hump' on the glass ribbon. The glass is in a fluid condition and proceeds to flow down through the holes.

Now we come to the actual glass-blowing operation. In the diagram is seen the continuous belt bearing the blow-heads which perform the blowing. As one 'hump' of molten glass starts to flow through the hole in an orifice plate a blowhead moves exactly into position and blows a puff of compressed air which transforms the blob of fluid glass into an embryonic glass bulb or 'blank'. The bulb will then proceed to swell, and its final shape and dimensions will be fixed by moulds which come up into position and enclose the embryonic bulb.

These moulds are worth particular attention. They are mounted on a moving belt which brings them up into position, so that the two halves of the split mould come to form a sheath round the embryonic bulb, and then the mould closes round it. At this stage in the procedure the air pressure from the blowheads increases so that the bulb swells to its final size rapidly; the moulds themselves are rotating, which is calculated to prevent the bulbs inside swelling irregularly. This moulding is a very delicate affair: each mould is cork-lined, and the heat from the bulb converts the cork into fine carbon which absorbs water from the cooling sprays playing on the moulds—the water vaporises and it is the cushion of steam between mould and bulb that accounts for the high polish with which the bulb leaves the mould.

When the blowing process is complete for a particular bulb, the mould opens, and we see that the continuous ribbon with humps on it has been transformed into a ribbon bearing a bulb at every point where there had been a hump.

The ribbon festooned with bulbs now reaches a rotating ribbon lifter; this cuts round the neck of the bulbs, a hammer tap then detaches the bulbs which fall off into the scoops on a turntable, and these scoops tip the bulbs off on to a moving belt which carries them through an annealing oven.

(*Right*)—The Ribbon Machine is seen on the right of the photo: on the left is the firehearth of the glass furnace. The Harworth Factory (*bottom right*), which is run by a new company formed by G.E.C. Ltd. and British Thomson-Houston Co. Ltd.

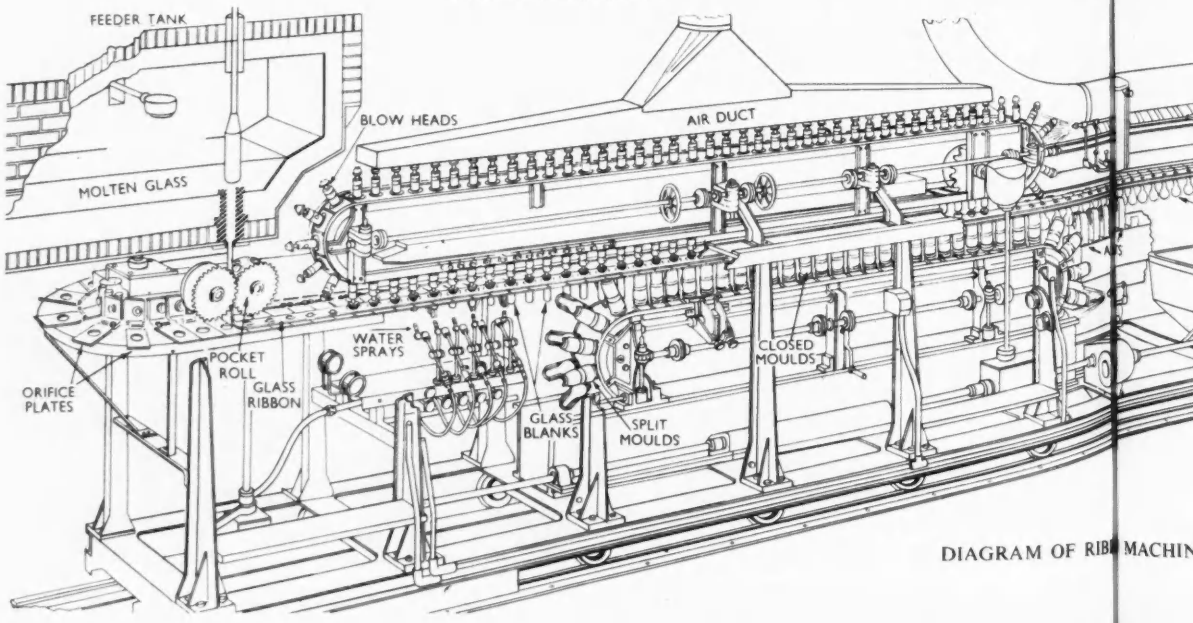
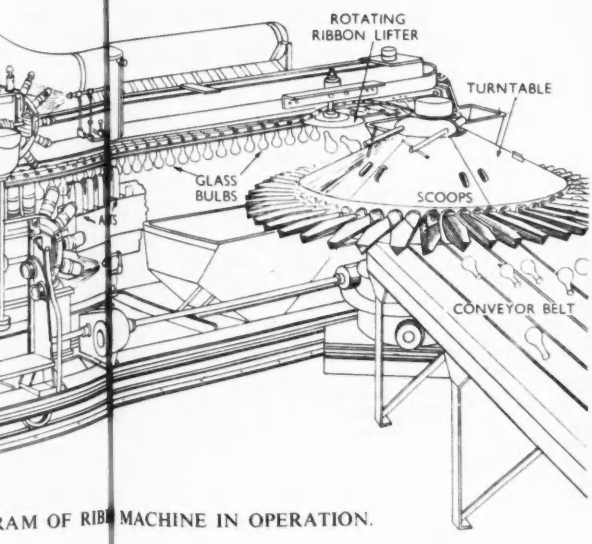
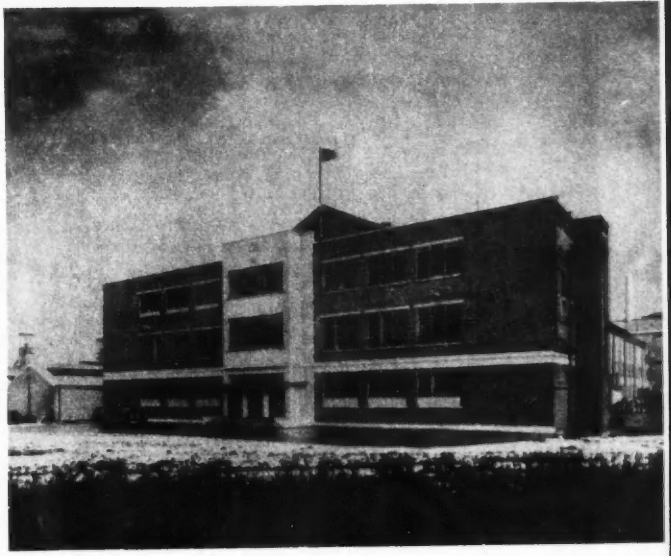
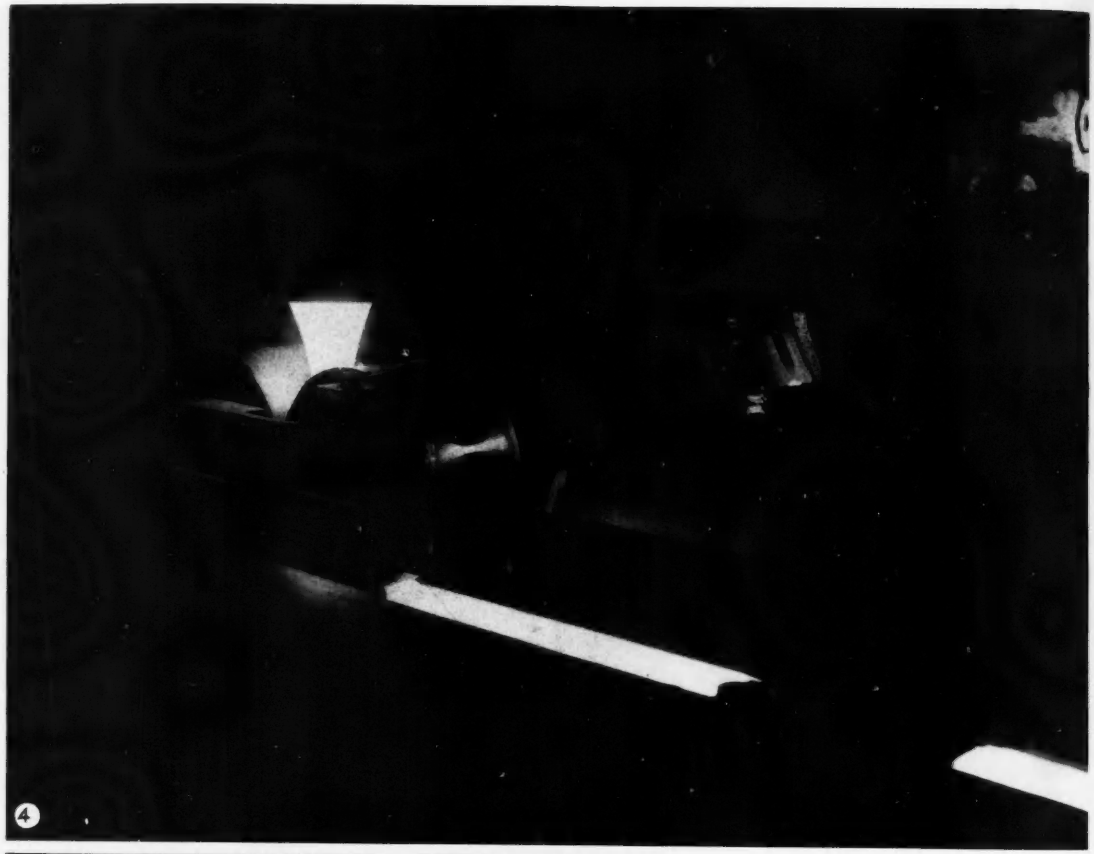


DIAGRAM OF RIB MACHIN



RAM OF RIBBON MACHINE IN OPERATION.





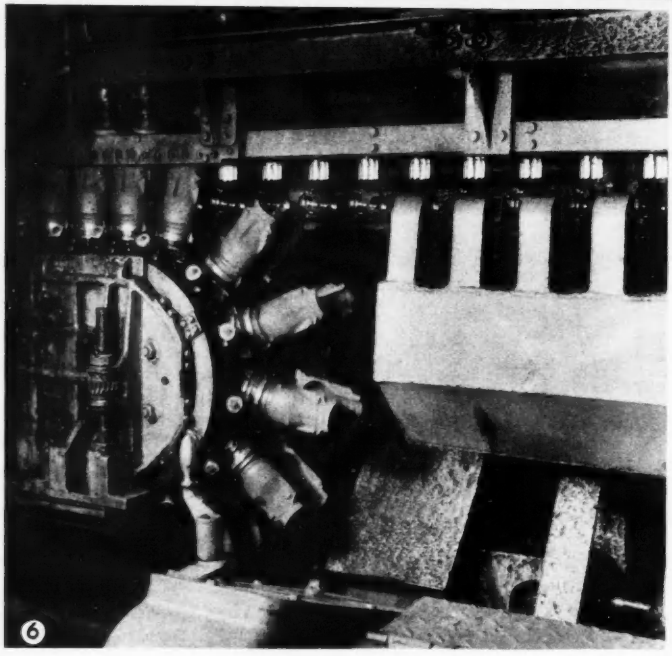


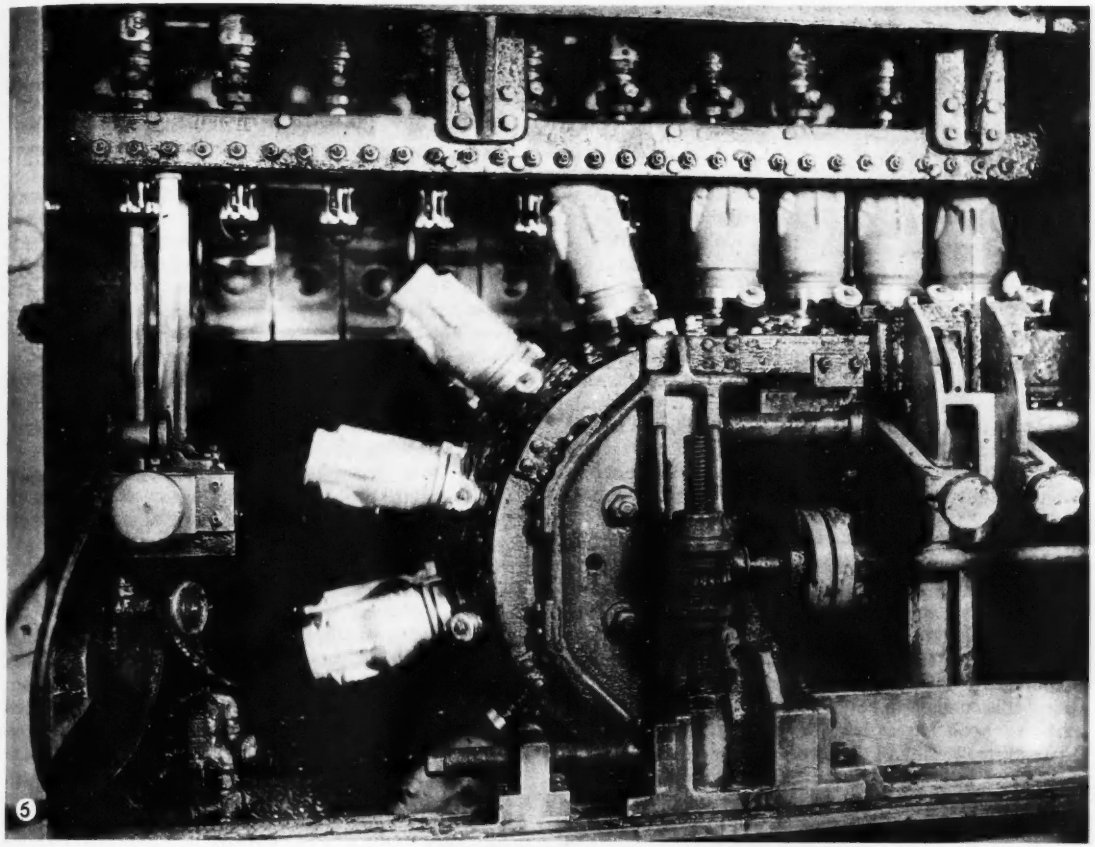
FIG. 4.—The stream of molten glass from the furnace is changed into a ribbon by its passage through the pair of water-cooled rollers. Note the concavities on the right-hand roller, which produce the series of 'humps' on the glass ribbon.

FIG. 5.—Embryonic glass bulbs (or 'blanks'), hanging from the ribbon, meet and enter the moulds.

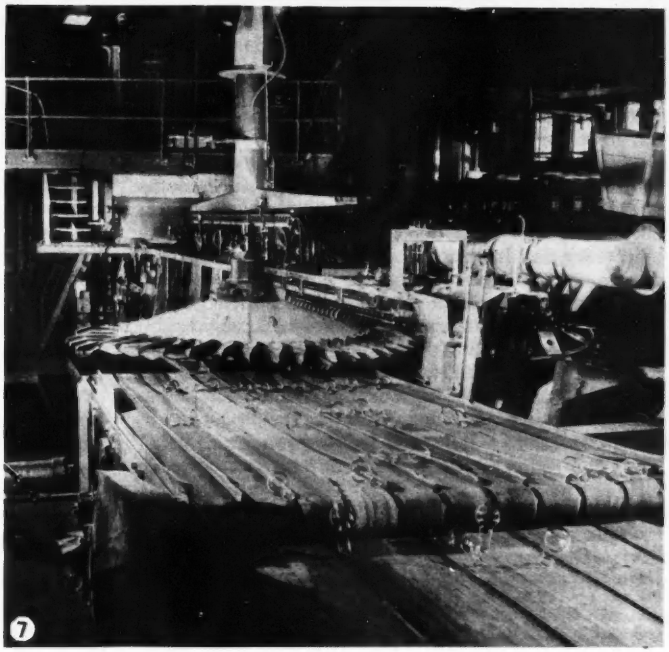
FIG. 6.—Finished bulbs leaving the moulds. To the right of the belt carrying the moulds are seen four sets of jets which blow cooling air on to the finished bulbs.

FIG. 7.—The bulbs have been detached from the ribbon and are dropped on the conveyor belt by the rotary turntable. The conveyor belt carries them through the annealing oven.

The factory makes its own glass; the raw materials for the glass manufacture consist of soda ash, dolomite, limestone, sand and felspar in addition to cullet (broken glass). All these materials are obtained in this country: the sand from King's Lynn in Norfolk, the soda ash from Northwich in Cheshire, the limestone from Buxton



in Derbyshire and the dolomite locally from a source near Doncaster. These materials are fed into a gas-fired furnace capable of making 150 tons of glass a day. The resultant glass contains very roughly 72% silica, 18% soda, 6% lime and 3% magnesia. The larger Harworth machine, with moulds at 3·9 in. centres, produces from 350 to 500 bulbs a minute in the 70 mm., 75 mm. and 80 mm. sizes for 75-watt, 100-watt and 150-watt general lighting service lamps. Operating on a continuous 24-hour schedule, this machine gives a daily output of approximately 500,000 bulbs. The smaller machine, in which the mould centres are at a 3-in. pitch, will produce the whole range of valve bulbs up to 44·5 mm. diameter, including all the miniature types, and lamp bulbs from the 25-mm. stop and tail light size up to and including the 65-mm. bulb for the 60-watt general service lamp. The output of this machine, which runs continuously throughout the 24 hours, is approximately 1,000,000 bulbs daily. The finished bulbs are packed and shipped to other factories which insert the filaments; our cover photo shows the kind of machine used in that operation.



Science in the Schools

DR. ERIC JAMES

High Master, Manchester Grammar School

IT is gratifying that the recent report of the Advisory Council on Scientific Policy* lays particular emphasis on the standards of science teaching in schools. Too many of the large number of reports, speeches and discussions concerned with the supply of scientists that have appeared in recent years, whether they deal with pure science, with technology or medicine, give the impression that the problems are simply those of the university or the technical college. It is too often overlooked that the contribution of scientific knowledge to our national life is completely dependent upon an adequate level of scientific education in the schools. This report draws attention to two specific questions, the position of science in 'public' schools, as distinct from grammar schools, and the supply of science teachers.

Discussing the first of these the committee expresses their belief that, in spite of the manifest changes in attitude of the past twenty years, it is still true to say that the atmosphere of the public schools is such that a due proportion of their pupils is not encouraged to take up scientific careers, and, indeed, that many of the ablest are actually discouraged from doing so. A strong case can be made against this contention. Some of the best among the independent schools have a level of science teaching certainly not surpassed by any of the grammar schools and superior to the great majority of them. The records of their pupils show, too, that they are making a quite remarkable contribution to the ranks of first-rate scientists, and thus it is clear that many of their ablest boys are choosing scientific careers. On the other hand, this is by no means true even of all the schools in the first rank, while in the public schools below that level it is often the case that neither the provision of laboratories nor of time in the curriculum is such as would encourage high standards in science teaching. But in so far as there is some truth in the committee's contentions, it springs mainly from causes other than material ones. The belief is still very strong, and not only in the public schools, that the sciences are not part of a liberal education in anything like the same way as some other subjects. Implicit in almost any educational discussion one finds the view that an early study of science must be regarded with the greatest suspicion as verging on dangerous over-specialisation. The unspoken assumption is usually present that 8–10 hours a week spent on Latin from the age of eight is not inconsistent with a broad, general education, while three or four periods of science at the age of twelve is opening the way to the production of narrow specialists. It is time that we re-examined that whole conception of general education which sees virtue in making a boy or girl do anything as long as it is not what really interests them. We must recognise more frankly, in particular, that the effects of a prolonged and genuinely educational study of science may for many boys produce better results than a delayed cramming for vocational purposes, which is what so often happens when we are too obsessed by the dangers of premature specialisation. The committee is probably right in thinking that such changes in attitude are particularly necessary in some of our public schools.

There is one other way in which the comments of the Advisory Council's report are probably justified. Though some of the public schools make an unsurpassed contribution to the supply of pure scientists, their output of students who eventually become technologists or of scientists below the highest grade is not so satisfactory. It appears probable that very many boys who, if they were in grammar schools, would go on to courses in science and technology at the provincial universities, leave the public schools direct for commerce or industry. In many cases they go into family businesses where a university training would be of great value. There is no doubt that many of the public schools must learn to recognise, as now they barely do, the existence of great departments of science and technology at, say, Manchester and Leeds, and send some of their boys to them instead of concentrating on Oxford and Cambridge for the ablest, and allowing the remainder to escape a scientific education both at school and university.

Much more important, however, than what the report says about the public schools, is its recognition of the shortage of science teachers in grammar schools and public schools alike. Here is a problem the national consequences of which may be far more serious than is even now generally realised. At present the situation is not obviously critical only because much of the advanced science teaching is being carried on by men of over forty-five. But even now many schools are without science staffs that are adequate in quality or quantity. In ten or fifteen years we may be faced with a situation in which the only expedient will be for university courses to be extended to remedy the deficiencies of the schools by giving instruction at levels which the universities are neither willing nor equipped to do. What is the solution? The Advisory Council's report is understandably vague on this aspect of the problem. "It may become necessary to take special measures to increase the numbers of science teachers in schools . . ." says the report. But what special measures has the Advisory Council in mind? To some extent, obviously, the financial position is to blame. We are working with a salary structure that postulates that all teachers are virtually worth the same, and pays a teacher who at some stage scraped through school certificate and underwent a two-year course in a training college the same basic salary as the man who secured a first in physics. The indiscriminate demand to raise teachers' salaries is no answer at all: the only real solution is to establish adequate differentials by which sixth-form work, which after all makes greater intellectual

* *Fifth Annual Report of the Advisory Council on Scientific Policy* (1951–52), published by H.M.S.O., Cmd. 8561, price 6*d*., which was discussed in last month's DISCOVERY (pp. 201–2). Almost the whole document is filled by the report of the Zuckerman Committee which reviewed Britain's future demands for Scientists and Technologists.

demands than much of what is done in technical colleges and all of the work of training colleges, receives adequate rewards. It will probably take a Royal Commission to bring this about, but sooner or later the hard facts of economic survival will make it necessary.

But financial considerations are not the only reasons why promising young men and women will not teach. It may well be that an even more powerful factor is the prestige of research, and it may equally be the case that we must ask whether we are not reaching the point where we are carrying more researches of the second grade than our educational system can support. Some experience of research is actually very valuable for the sixth-form teacher, but one cannot resist the impression that we have lost our sense of proportion, that too many young men are encouraged to go on for too long as mediocre research workers when they would be better employed as teachers, and that industry is attracting too many young men of high calibre to research appointments involving work which is often of a purely routine character. Whether this be true or not, the fact is plain that unless a proper proportion of young men go into the schools, the whole foundation of research in the universities and industry alike is in danger. The universities can help by pressing upon students the claims and attractions of grammar school teaching. It may be that the situation is so urgent that teaching should be regarded as an alternative form of national service. Certainly it should be made plain to good science graduates that it is unnecessary for them to spend a year in professional training, and that they will not prejudice their career by not doing so. Whatever the means adopted, and it is probable that all these and others must be tried if a critical situation is to be avoided, one must be grateful that the Advisory Council has drawn attention to a problem so vital that, if it is not solved, all our plans for the development of science and technology in the service of the nation and of mankind will be built upon sand.

Prof. Solly Zuckerman, chairman of the special committee whose report on scientific manpower in relation to science teaching in schools is discussed by Dr. James.

CAREERS IN PHYSICS

Books on careers vary greatly, ranging in their approach from the mere catalogue of facts to the enthusiast's special pleading. What real purpose do these books serve? Writers and publishers of them seem to be almost as much in the dark on this question as those who have to review them. Is such a book actually bought by pupils and earnestly studied to give them a line on what they want to be? Furthermore, do parents who seriously set out to help their children, choose careers by buying the little manuals and studying them? In both cases the book needed is a colourful one capable of arousing enthusiasm in the reader, the book intended for the schoolboy requiring more illustrations and rather fewer facts than the one intended primarily for the parents. On the other hand, do parents buy manuals to acquire further facts for their children about careers on which the children are already keen? In that case the book needed is one that is factual, accurate and comprehensive. A fourth type of reader may also exist: the graduate who is undecided about the way in which he wishes to utilise his academic qualification. The fifth type of reader is the schoolmaster, trained to dip into books and build the facts gleaned from them into lessons and lectures.

These questions are raised by the publication of *Physics as a Career* by Norman Clarke (published at 5*s*. by the Institute of Physics, 47 Belgrave Square, S.W.1). Like so many similar booklets (this one is very short and has but 49 pages of text) it fails to be wholly satisfactory in meeting the needs of any one of the five categories described above; perhaps this was inevitable with any effort which aims to satisfy all five types of reader at the same time in too small a space. The book is illustrated with photographs which are clearly intended to be inspiring, but these pictures are of stock subjects that have already been shown in dozens of lay journals—a high-voltage generator, a physics lab., an electron microscope, etc. The writing is bald and lacks freshness, with the result that no schoolboy is likely to be excited by it.

The facts are accurate and there is useful information about salary scales. These may appeal to the prudent parent, who will at the same time be unable to learn enough about details because of the generality of the propositions. The book, being so small, cannot be comprehensive—atomic energy research at Harwell, for example, is not even mentioned, and the book lacks a positive statement about the way in which such research establishments recruit their youngest staff. (The N.P.L., for instance, recruits school pupils locally, and these are given facilities for studying to degree standard—a fact which is not stated in the book.)

Nobody would be grudging enough not to give credit to Mr. Clarke for the accuracy of his information and the thought he has given to his subject. Nevertheless, this book succeeds in providing yet another object lesson of the way in which the presentation of facts about careers still needs a great deal more thought, not only by the Institute of Physics and other similar professional organisations, but by publishers and educationalists as well. In conclusion it must be added that no serious science master can afford to be without this booklet because some of its information —such as that about hospital physicists—supplements what is lacking in others. But comprehensiveness was the one quality which we are entitled to expect in an official career-guide issued by the Institute of Physics, and this is absent.

Continued from p. 228

The Battle Against Trypanosomes

GEOFFREY LAPAGE, M.D., M.A., M.Sc.

THE methods used to prevent infection of man and domesticated animals by tsetse flies and other vectors of trypanosomes, and the methods used to control or exterminate these vectors, will briefly be described.

When the aim is to prevent the infection of man and animals by controlling the insect vectors, the control method has to be varied according to the species of insects involved. The main vectors are:

1. Blood-sucking bugs, which transmit *T. cruzi* in South America.
2. Horseflies and stable flies, which transmit mechanically *T. evansi* and *T. equinum*, and are the only vectors of these two species of trypanosome.
3. Tsetse flies.

Blood-sucking Bugs

These fierce bugs which are called 'kissing bugs' (because they often bite near the lips and eyes) and also 'assassin bugs', are constantly being infected with *T. cruzi* from the blood of the armadillo and other wild animals that are alternative hosts of this trypanosome. It is practically impossible to keep the bugs out of the mud and thatched dwellings in which many of the people live and very difficult, if not impossible, to prevent them from attacking the infants and young children who suffer so severely from the disease caused by *T. cruzi*. This trypanosome is, however, not inoculated by the bite of the bug, but by the rubbing of the droppings of the infected bug into the site of its irritating bite or into the membrane lining the socket of the eye or into other mucous membranes; repeated exposure to bites of the bugs is usually necessary for infection with the trypanosome. The bugs are susceptible to spraying with DDT or benzene hexachloride (Gammexane), but the best policy is to rehouse the people in dwellings that will keep out the bugs, care being taken to keep out also the armadillos that frequently harbour the trypanosome and burrow up through the floors of dwellings.

Stable Flies and Horseflies

Stable flies (*Stomoxys*) resemble house flies in appearance and their larvae, like those of house flies, develop in decaying organic material; they thrive particularly in such moist media as soggy hay or lawn cuttings, which should therefore be removed or dried, or sprayed with a fly-repellent or an insecticide. DDT and benzene hexachloride are effective against the adult flies.

The horseflies (*Tabanus*, *Haematopota*, *Pangonia* and *Chrysops*) have aquatic larvae. The eggs are usually laid on plants growing in or near water. The larvae leave the water to pupate on drier land. The adults, which are most active on hot, sultry, sunny days, inflict irritating wounds with their relatively coarse mouth-parts and often bite several times before they have gorged on blood. This habit favours the mechanical transmission of trypanosomes, which do not go through a cycle of changes in these flies as those that enter tsetse flies do. Horses may be protected from tabanid flies by means of nets and their dwellings may be screened; fly-repellents are usually not effective. Drainage helps by removing the breeding grounds of the flies, and horses and camels should be kept well away from likely breeding places in streams, marshes and wet places. The adult flies have a habit of dipping their bodies in water as they skim over it and paraffin poured on the water surface will therefore kill many of them.

Tsetse Flies

Tsetse flies belong to the genus *Glossina*, which is represented only in Africa. They occur over an area of about four and a half million square miles, which is equivalent to about 50 times the area of Great Britain. This territory extends from the southern Sahara to the northern parts of the Union of South Africa. Over this huge tract of country the distribution of the different species of tsetse flies varies. They exist in regions called 'fly-belts', which are never for long quite the same. Not all the conditions that govern the distribution of the different flies are known, but in general it is controlled by the need of the flies for the blood of particular kinds of vertebrate animals and by climatic conditions.

Some species, such as *Glossina palpalis*, *G. tachinoides*, *G. pallidipes*, *G. brevipalpis* and *G. fusca* are dependent in varying degrees on the shade and humidity that they find along the thickly wooded shores of lakes and rivers. They are often called *riverine species* and they are not usually found in more open country. Along rivers and lake-shores different species of them are associated each with certain particular types of vegetation. Riverine species tend to travel up rivers in the wet season and down them to the heavier bush lower down when the dry season comes. Other species, such as *G. morsitans*, *G. swynnertoni* and *G. austeni* are found, not along the shores of lakes and rivers, but in more open savannah country; but in this kind of country they need the shade of certain types of trees, thicket or bush. They can be called *non-riverine* or bush and savannah species. There is no space here to go into details about the particular kinds of vegetation favoured by the different species of tsetse flies, but these details play an important part in tsetse-fly control.

Both male and female tsetse flies suck blood, although they also feed on plant juices. Some species do not normally seek human blood. Thus *G. palpalis*, one of the chief vectors of West African human trypanosomiasis, feeds on the blood of crocodiles, lizards and amphibia that it finds in the rivers and lakes that this species frequents. The other important vector of human West African trypanosomiasis, *G. tachinoides*, usually lives away from human settlements and prefers the blood of game and river animals, although it can subsist on human blood alone. *G. austeni*, the vector of nagana of domesticated animals in

Zanzibar, also does not readily bite man, and cattle are used to attract and catch it. *G. morsitans*, the most widely distributed of all the species of tsetse fly, and the East African species *G. pallidipes*, and *G. swynnertoni*, the commonest species in Tanganyika, all of which are non-riverine species, are all 'game flies' and normally feed on the blood of wild game, especially that of ungulates. *G. morsitans* and *G. pallidipes* readily feed on wild pig.

Tsetse flies do not lay eggs. Their larvae develop one at a time inside the body of the female fly and are fed there by structures called 'milk glands'. The mature larva is deposited by the female fly in soil, under fallen trees or in the bark of trees. The different species choose different sites for deposition of their larvae. The larvae turn into pupae, which are readily killed by sunlight. From the pupa the adult fly emerges after about five weeks. Each female produces less than twelve larvae and then dies. As one entomologist has said, it is remarkable that tsetse flies, which produce so few young and are less numerous than other insects, and are dependent upon certain degrees of temperature and moisture and upon the shade of certain types only of vegetation and also need, every three days or so, a meal of the blood of certain types of animals, can resist so successfully human efforts to exterminate them.

Tsetse flies in general are most active during the daylight hours, feeding more in the early morning and evening than during the heat of the day and retiring then into the shade of the types of vegetation that they prefer.

They hunt by sight and fly a few feet from the ground, with a darting flight, buzzing as they go. They are attracted by moving objects and some species, such as *G. morsitans*, will follow men and animals for considerable distances. *G. palpalis*, on the other hand, which is a riverine species, does not usually travel far from the lake-shores and rivers where it lives and may attack human beings and animals at fords and drinking places. In general, tsetse flies are repelled by white skins and clothes and are attracted by dark or brown colours, so that they prefer the skins of negroes to those of white men and are attracted by khaki.

These brief notes on the biology of tsetse flies show that the task of preventing them from biting human beings and domesticated animals or of exterminating them is a difficult one.

Apart from the removal, mentioned below, of whole human communities and their domesticated animals out of reach of the flies into areas cleared of the flies, tsetse flies (apart from one or two species) can be avoided by limiting travel through fly-belts to the night-time, when most species are inactive, though some bite at dusk or in moonlight. Fly-screens applied to doors and windows of houses and of vehicles and steamboats, the motion of which may attract the flies, may help to keep the flies out. Human beings can avoid wearing dark-coloured or khaki clothing that attracts the flies more than white clothing does. Insect-repellents may give some protection. Pyrethrum extracts have been used with some success for the protection of some animals (donkeys, for example), but on the whole repellents are not very effective.

Extermination of the tsetse flies, by methods now to be described, is the only reliable means of conquering them and of making territory infested by them permanently habitable by man and his domesticated animals.

DDT sprayed on fly-screens and cattle will kill tsetse flies by adhering to their feet, and it will discourage the flies from biting; it does not stick well, however, to the hair of cattle and soon rubs off unless it is mixed with gum. Insecticides sprayed by aeroplane over the habitats of riverine species may halve the length of life of these species and may thus make it impossible for the trypanosomes to develop in them to the infective phase that alone can infect new hosts; cyclical transmission may thus be interrupted. Insecticides are, however, not likely to give permanent control of the flies.

Specially constructed traps are also used, and these have reduced the numbers of *G. palpalis* and *G. pallidipes* in areas where these flies have been very numerous, but traps are less effective against other species.

Log-traps and similar devices may be used to induce the flies to deposit their larvae under them, and the pupae may then be collected and destroyed. Attempts to eradicate *G. palpalis* from an area in Kenya by attacks on its breeding grounds were not successful, and the Symes block method of clearance of vegetation was for this reason devised as a successful alternative.

Hand-catching seems, at first sight, to be an unpromising method, but it may, under certain circumstances, be valuable. It has been found to be more effective against *G. palpalis*, for example, than traps. It is a feature of the Symes block method of clearing vegetation that was successful against *G. palpalis* along the shores of Lake Victoria and the rivers in Kenya and also along rivers in the southern Sudan. By this method blocks of riverine bush, about two miles long, are separated by clearings 1000 yards wide. Paths are cut in the vegetation along river banks or lake-shores, and these paths are patrolled by persons with nets on several days of each week and as many flies as possible are caught. This method reduced, in one block, the numbers of flies caught from 5000 in three months in 1933 to seven in nine months in 1935, the cost being £40 a mile, in contrast to a cost of £250 per mile needed for complete clearing of the vegetation.

Cattle and other animals may be used as bait to attract flies before they are caught, and this device can be used to detect the presence of tsetse flies in areas in which their presence is in doubt. Periodical journeys with these bait-animals, undertaken to count the number of flies coming out to feed, were called 'fly-rounds' and this was one of the earliest methods used to find out the numbers of tsetse flies in a given area.

Clearing of Vegetation

This is one of the most effective methods of attacking tsetse flies. Its object is to remove, over limited areas, the particular types of vegetation upon which the flies depend for the shade and humidity they must have. Effective barriers are created in this way, which prevent the spread of the flies. Such clearances may be *aggressive* against the flies, or *defensive* of man and animals. Clearing is best done early in the dry season and, except when it is permanent, needs annual attention and maintenance. Clearing is often combined with measures of land reclamation and the country thus protected from tsetse flies is then colonised by people and domesticated animals removed to it from fly-ridden areas.

The Tsetse Fly Problem

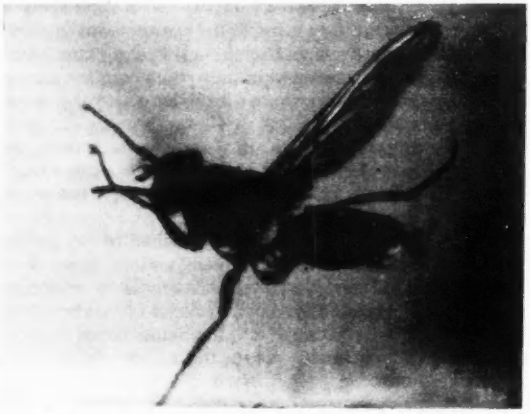


FIG. 1.—The Tsetse Fly, *Glossina palpalis*, in flight.

FIG. 2.—These flies spread trypanosomaisis over an area equal to 4½ million square miles—50 times the area of Britain.

FIG. 3.—Breeding-ground of two tsetse flies, *Glossina morsitans* and *Glossina tachinoides*; note the absence of undergrowth in the thicket. This photo was taken at Sherifuri, N. Nigeria, by Dr. Wigglesworth. FIG. 4.—Partial clearing in the Ihara District. Removal of the thicket and low trees kills off *Glossina morsitans* and *G. tachinoides*; the tall mahoganies seen here can safely be spared. (*Photo by Dr. T. A. M. Nash.*)

FIG. 5.—Felling large trees as part of bush-clearing work to control tsetse fly in Tanganyika. (*Photo by H. S. Leeson.*)
FIG. 6.—This picture was taken by Dr. T. A. M. Nash three months after the trash from the clearing had been burnt. Already thick riverine grasses have colonised the ground and will prevent soil erosion. River Galma Causeway at Kudaru.

Clearing can be effected by poisoning selected trees with arsenic or by ring-barking; alternatively, it can be achieved by felling and burning the trees and vegetation. Bulldozers are very useful and are said to be the most important weapons against tsetse flies yet introduced into Africa.

Selective Clearing is the name given to the removal of certain species of trees favoured by certain species of tsetse fly.

Discriminative Clearing is the practice of complete or partial clearance of certain sites or the removal of certain types of vegetation from these clearings or from wider areas. It is useful against non-riverine species, such as *G. morsitans*, which prefers to shelter in open woodland and likes miombo, or against *G. swynnertoni*, which prefers thorn bush. Clearings a mile wide on the great plains along the edge of the thornbush seem to be successful barriers against *G. morsitans* and *G. swynnertoni*.

Against the riverine species *G. brevipalpis* and *G. pallidipes*, which depend on the humid shade along rivers, lakeshores and drainage lines, undergrowth is cut out, leaving only large trees with clean stems. A clearing 10 yards wide for a quarter of a mile may thus be made. Against *G. palpalis*, another riverine species, clearing the foreshores of lakes and rivers is effective, but such clearings should extend for a quarter of a mile from cultivated land and, if they are to be successful, all heavy forest and thicket must be removed. Against *G. tachinoides* it is sufficient to clear riverine vegetation to a width of 10 yards, but on main roads all trees should be cut for a depth of 100 yards on each side of the road and all thicket to a depth of 300 yards.

In Nigeria, the tributaries of the main rivers dry up in the dry season and the tsetse flies then retreat from them, but come back during the wet season. *Barrier clearings* are therefore made to prevent their return, and these have been a prominent feature of the Anchau Settlement mentioned below. Other schemes of protective clearings have been carried out in Nigeria in South Katsina and Zaria, and it is hoped that, when they are completed, about 200,000 people will be protected from the flies.

In the Gold Coast, clearings, combined with mass treatment of the people, have been effective. In 1937, 30,000 square miles of country were involved, in which 5–15% of the people were infected with trypanosomiasis. The vectors were the riverine species *G. palpalis* and *G. tachinoides*, and the disease caused depopulation of the Black Volta river and its tributaries and consequent overcrowding of the watersheds between the rivers, with the consequence that much soil-erosion and land hunger resulted. The clearings made aimed at preventing contacts between man and the flies at river crossings and waterholes. Combined with mass treatment these *protective clearings* reduced trypanosomiasis in five years by 60–80%, but the decline of the disease was not progressive. It was found that the species of fly concerned move freely along the river banks at all seasons, so that small numbers of them cross clearings even three to five miles long, as was also found in Kenya with *G. palpalis*. Clearings half a mile long were entered by 25% of the flies, and clearings of 200 yards or less might actually cause an increase of the flies at the points they were meant to protect. It was also found that localised small clearings do not cover all the contacts between man and the flies, and the necessary eradication of all woody vegetation is expensive and may cause erosion of river banks and silting up of water-holes. Nor can small clearings control trypanosomiasis of animals. Study of the flies showed, however, that they are most vulnerable when they travel down the rivers in the dry season and concentrate in limited and well-defined foci lower down, and it was found that the vegetation in these foci was characteristic and that certain kinds of trees and shrubs in them were essential to the flies. Selective clearing of these trees and shrubs, carried out over 600 square miles of the Lawra district, caused, in 1941–2, rapid disappearance of dense colonies of *G. palpalis* and *G. tachinoides* throughout the Kamba river. Selective clearing thus makes possible the return of the people to good land and grazing in the river valleys, where controlled settlements can be established. It was, however, found that the cost and labour of the annual maintenance required by clearings of this type could be avoided by eradication of the vegetation of the fly-belt, and a stability of the change thus effected on the Gold Coast from evergreen forest to open tree-grass plant associations was attained so successfully that, in 1949, about half the areas treated had been permanently reclaimed and needed no maintenance.

Barriers of Dense Vegetation may be useful, because they are so thick that the tsetse flies cannot penetrate through them, so that they limit the spread of some species of the flies. They have been found useful against such non-riverine species as *G. morsitans* and *G. swynnertoni*.

Prohibition of Use of Grass-fires

The burning of grass, practised by native hunters and others, destroys the young seedlings and shoots and interferes with the normal succession of vegetation and the normal thickening of woodland. It may also destroy or drive away ants that prey upon the pupae of tsetse flies. Prohibition of grass-fires, know as *fire-exclusion*, has been used against non-riverine tsetse flies. It is believed that it retains the grass covering of the land and allows the formation of a mat of grass, which probably increases the moisture in the soil and this adversely affects the pupae of the tsetse flies. It may also increase the humidity of the air, and this may help to prevent the production and deposition of larvae of the flies. It also encourages ants that prey upon the pupae and allows thickening of woodland. Early grass burning may, however, densify vegetation, because the early shoots are not burned back so severely as they are by fires later in the season. Prohibition of grass-fires has been found to be a promising measure against *G. morsitans* and against *G. swynnertoni* in Tanganyika, but there is no evidence that it affects *G. pallidipes*. In northern Nigeria, however, increased density of woodland, produced by prohibition of grass-burning, provides shelter for *G. morsitans* and encourages its survival.

Control or Destruction of Wild Game

The aim of this practice is to remove the wild animals (antelope, wild pig, etc.) in whose blood the trypanosomes can live without causing disease, so that the wild animals are *reservoirs* from which the tsetse flies transmit them to man and his domesticated stock. Destruction of game has

been used chiefly against the non-riverine species of tsetse fly, *G. morsitans*, in Rhodesia and Bechuanaland. This species feeds primarily on the blood of game and takes, when this is not available, the blood of domesticated stock and man, in that order of preference. It frequents hot, dry areas, but needs the shelter of particular types of vegetation, such as miombo and will not go into areas devoid of these types nor into areas into which game will not naturally go. It may also be limited by visual barriers and it retreats from human agricultural activities and from fires made by man. A settlement of 200 people per square mile may, in fact, eliminate *G. morsitans*.

The efficiency of the destruction of game has been proved in Rhodesia, where the measures taken included reduction of game along the edges of country free from the fly, the creation of zones ten miles or more wide free from game along the boundaries of farms and the control of motor traffic of hunters and prospectors. By 1939, at least 6000 square miles of country had been cleared of tsetse fly and roads had been opened to transport by oxen. In Tanganyika, however, experts doubt the efficacy of game destruction and many consider it unjustifiable. Apart from the aesthetic and humanitarian arguments, strongly held by many experts, it has been argued that the fly may subsist on wild pig, which cannot be sufficiently thoroughly destroyed; that there is no evidence that big game can be significant reservoirs of the human trypanosome *T. gambiense* and that they are only minor reservoirs of the other African human trypanosome *T. rhodesiense*; and that, although big game are reservoirs of trypanosomes that cause diseases of domesticated stock, the destruction of them can never be sufficiently effective, because so many domesticated animals have latent infections with trypanosomes, which serve to maintain the diseases, without the help of reservoirs in big game. Further, the destruction of game may remove the natural food supply of the tsetse flies and may force them to feed on domesticated animals and man. This may happen especially if apparent success of game destruction leads to a relaxation of precautions against infection of man and domesticated stock and to an increase of the numbers of the latter. It has been argued in favour of game destruction that *G. morsitans* cannot persist without the blood of game and that the destruction of game (and of cattle) by rinderpest has caused a virtual disappearance of the fly; but some experts consider that, when the decline or disappearance of the fly has coincided with epidemics of rinderpest, factors other than the loss of its main food supply have been responsible, and it has been shown that *G. morsitans* can exceptionally exist on the blood of man and animals, although it cannot subsist on the blood of birds.

Experiments have been made to find out whether fences and palisades will keep wild animals away, and these have been successfully used; but they are expensive and require constant maintenance, and discriminative clearing is likely to give more lasting results.

Controlled Human Settlement

The removal of whole human communities to areas freed from tsetse flies, or protected from them by clearings, or the control of human activities without moving the people, are effective methods of avoiding the flies. The removal of whole populations creates complex problems that include, not only the administrative, social and economic consequences of such removals, but also such possible consequences as soil erosion created by overpopulation of the new areas colonised. Desirable measures may create difficulties, because they conflict with traditional native practices. Further difficulties may arise from the fact that domesticated animals are, to the African native, not only sources of food, but also evidence of power or social position and they may be required, whether they are in good condition or not, for such purposes as bridal dowries or for religious ceremonies, and measures proposed or taken to protect the stock or to improve their condition may be vigorously resisted by the natives. This complex of problems has, nevertheless, been successfully tackled, a notable example of this being the Anchau Settlement in Nigeria, which involved an area of 7000 square miles. It required surveys, map-making, the building of roads, the sinking of wells, the study of local soils and vegetation, the creation of clearings and barriers against the flies, various investigations of native agricultural methods (some of which may be more effective against certain species of tsetse flies than European methods are), monthly fly surveys and various building projects and plans for the diagnosis of human trypanosomiasis and for the prophylactic and curative treatment of it with drugs and the training and organisation of teams sent out to carry out this diagnosis and treatment. It will be evident that the policy of removing human populations to areas that have been protected from the tsetse flies involves the simultaneous study of a variety of difficult and interrelated problems and its success is a great tribute to all those who have planned and carried it out.

This brief account of trypanosomes and of the methods that are used to control the harm they do to man and his civilisation indicates the most important elements in the complex and fascinating problems requiring solution, and the short bibliography appended below will enable interested readers to obtain further and more detailed information.

(All illustrations, with the exception of those credited in the captions, by courtesy of I.C.I. Ltd.)

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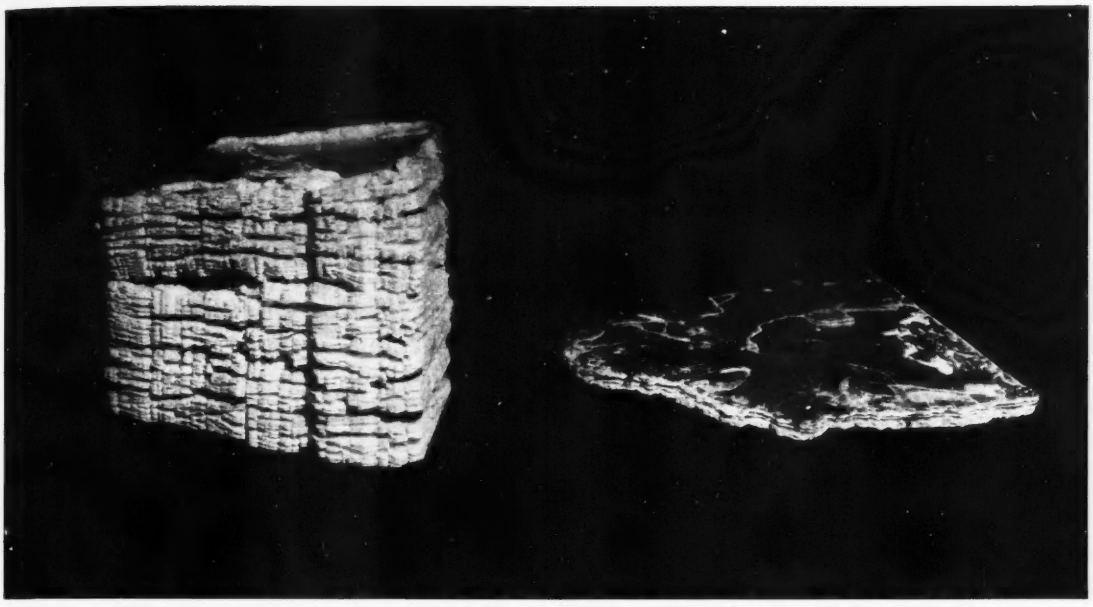


The permanent expansion of vermiculite when heated is its most remarkable property. The swelling effect or 'exfoliation' is demonstrated here with a 'book' of vermiculite which has been cut in half; the left-hand piece was heated at 900 C. and the individual leaves of the 'book' have swollen enormously. Swelling to 30 times the original size has been recorded for some specimens of vermiculite; 15 times is quite usual. The exfoliated vermiculite is an extremely light material; the apparent specific gravity of a mass of vermiculite can be as low as 0·087. (*Crown Copyright Reserved.*)

Vermiculite: A Versatile Mineral

A. GRAHAM THOMSON

In 1941, the managing director of an enamelling firm in Durban, South Africa, showed the writer a new process for enamelling porcelain, based on vermiculite mined in the Transvaal, by which a variety of metallic finishes could be obtained. Ordinary commercial grey turned to silver, buff to green, yellow to brass, and a range of pastel shades with a metallic finish could be achieved. This metallic effect, it was claimed, was so durable as to be almost indestructible. A sample of enamel made by the new process was immersed in sulphuric acid for half an hour, soaked for another half-hour in nitric acid, then dipped in saltpetre, and finally plunged into spirits of salts. Though the enamel itself was destroyed, the metallic surface still remained.

This must have been one of the earliest applications for vermiculite to be developed within the British Commonwealth, for it was only in 1938 that this unique and highly versatile material was first produced in commercial quantities outside the United States. Thirty years ago vermiculite had no commercial applications and was regarded as an entirely useless mineral. World production started in 1923, when plans were made to work a deposit in Colorado, refine the ore and prepare the product by roasting. The intention was to use the treated product as an insulating material for steam pipes, refrigerating equipment, insulating bricks, wall boards, etc. About the same period it was also decided to work a deposit in Montana and sell the expanded or exfoliated material as an aggregate in magnesium oxychloric cement products, or as a lightweight substitute for cork in all types of heat and insulation. Vermiculite is now produced in the United States by several concerns, the bulk of the output being obtained from the Libby deposit in Montana, which has been described as a mountain about a thousand feet high and nearly a square mile in extent, consisting wholly of vermiculite.

For nearly twenty years the United States was the only country in the world producing vermiculite and it was able to develop a wide range of important applications before the rest of the world started to carry out large-scale investigations. The American demand has never stopped expanding, and in 1950 sales within the United States reached the record total of 185,800 tons. Since the war vermiculite has become available outside the U.S.A. South Africa is now a very large producer, and exploitable deposits have been discovered in other Commonwealth territories.

Vermiculite had long been known to South African prospectors as a mineral frequently found in the corundum fields of the northern and eastern Transvaal. Originally thought to be merely 'rotten mica', it was not regarded as being potentially of any commercial value until 1936, when a sample was sent to the United States and identified as vermiculite. Production started in 1938 with an initial output of 215 tons. With Government encouragement it has been vigorously expanded and amounted in 1950 to

41,753 tons. Besides being virtually the sole supplier of the British market, South Africa is actually shipping vermiculite to the United States, where demand has outstripped domestic production.

The Union's most important deposit is situated at Palabora in the eastern Transvaal, and it has been authoritatively stated that this occurrence is actually superior to the Libby deposit in both extent and quality of the ore. In this area the mineral was first considered to be merely an accessory to apatite, but exploratory work revealed an area of serpentine which contained large reserves of vermiculite. Systematic prospecting and sampling by the Mines Department of Crown land withdrawn from public pegging has indicated reserves of not less than 5¾ million tons of recoverable ore. The area sampled represents only a very small proportion of the Palabora complex, and other deposits of economic interest have been recorded elsewhere in the Transvaal. The ore body at Palabora has been explored by pits over an approximately circular area 900 yards in diameter, and by sinking shafts, which remained in the vermiculite-bearing serpentine to a depth of 60 feet. Mining presents no difficulty and is undertaken by African labour at very low cost. The South African material can actually be delivered in New York more cheaply than the product of the Libby mine.

Since 1937, the Minerals Research Laboratory in South Africa has interested itself in the examination of vermiculite from the Transvaal deposits in order to further its economic development and use. In the Palabora area the vermiculite occurs as large platy aggregates, which are capable of fairly easy sorting and grading, and a suitable flow-sheet was worked out. Since the occurrences seemed to be extensive enough to warrant a very energetic pursuit of large markets, producers were advised that a liberal outlook for development and experiment under competent guidance was likely to be well repaid. Several companies are now in production and very large programmes for further expansion are reported to be under way.

In 1950 Southern Rhodesia produced 700 tons of vermiculite and became the third largest producer (excluding the U.S.S.R., whose output is unknown). The Rhodesian production has since been greatly expanded and now exceeds 100 tons a month. One of the largest producers has signed a contract with the United States for the entire output of the mine concerned, apart from a comparatively small amount earmarked for local consumption. Several occurrences have been located in both Western Australia and Queensland, and some production on a relatively small scale has been recorded in recent years. Deposits of economic interest have also been discovered in Kenya, and occurrences have been reported from Tanganyika, Uganda, Nigeria and the Gold Coast.

Vermiculite is an alteration product of phlogopite and biotite micas, caused mainly by the oxidation of the iron components or by a change in their water content resulting from hydrogenation. Its colour varies from white to yellow, bronze, brown and green. The most important of its unusual properties is that it expands on heating to about twenty times its original volume. The exfoliated product weighs from 2½ to 8½ lb. per cu. ft. according to grade. Besides this remarkably low density it has other useful properties such as comparatively high refractoriness at low temperatures, low thermal conductivity and chemical inertness. It is a non-conductor of electricity.

South African vermiculite is shipped to Britain in various grades of crude ore, which are treated in the United Kingdom to yield products of the types most suitable for particular applications. Compared with consumption in the United States, the British demand is still relatively small, since the material has only become available since the war, but very rapid headway is now being made. In 1950, shipments to this country from the Union amounted to 5149 tons valued at £31,836.

Britain's largest market for vermiculite is in the building field. In large constructions such as public buildings, schools and blocks of flats, import difficulties have encouraged the conservation of timber by substituting concrete, either prestressed or *in situ*, and constructing roofs of the flat or barrel-vault type. Since all forms of concrete are subject to expansion and contraction, an insulating medium must be introduced. In order to avoid additional weight it is essential that this material should be as light as possible. Vermiculite averages 5 lb. per cu. ft. compared with 120 lb. per cu. ft. for sand. Moreover, the fire-resisting properties of vermiculite allow the thickness of the production to be substantially reduced. Vermiculite has a melting point of about 2500° F., and produces a plaster one inch of which gives up to four times the fire-proofing effect of ordinary plaster. An inch of vermiculite concrete gives the same fire-proofing protection as over a foot of ordinary concrete.

Used in bricks, floors, blocks and walls, vermiculite concretes give nearly ten times as much thermal insulation as does the same amount of sand-and-gravel concrete. An eight-inch thickness of vermiculite brick will give the same amount of protection against heat and cold as will a six-foot thick wall of ordinary masonry. Vermiculite plasters also have outstanding acoustical properties, which render them specially suitable for the walls and ceilings of broadcasting studios, schools and hospitals. They are highly resistant to moisture and will not deteriorate or give off any objectionable odour when wet. Walls plastered with vermiculite are crack-proof, and nails can be driven into the plaster.

In the United States millions of tons of steel are saved every year by encasing the steel stanchions and columns of buildings with vermiculite concrete instead of with the ordinary cement-and-sand concrete. The actual saving may be anything up to 100 per cent in dead-weight, made up in fillers. In one large American building 15,634 tons of dead-weight were eliminated in this manner, the saving in steel amounting to 1,880 tons, valued at 235,000 dollars. This saving in construction dead-load is bringing about radical recalculations in architectural design.

There is an increasing demand for vermiculite in the form of precast blocks, bricks and slabs, both solid and hollow. Vermiculite is the basis of a prefabricated housing project undertaken by a South African firm which, after a large amount of experimental work, developed and patented suitable bind materials for mixing with the mineral to give blocks or slabs with high crushing strength, high heat-insulating value and weather-resistance. Different methods of preparation and alternative binders were combined to produce flooring and roofing materials of various types. It was claimed that vermiculite roofing could be moulded or

Walls up to 8 in. thick can be erected by spraying a vermiculite-cement mixture on to a framework consisting of two vertical sheets of wire netting with a space between.

coloured to resemble tiles or even thatch. Blocks, bricks and flooring tiles of locally mined vermiculite are also being manufactured near Salisbury, Southern Rhodesia.

Vermiculite coarse granules are extensively used as a filling in factories, offices and homes, for both thermal and sound insulation. Vermiculite is also used as a loose packing between wire-mesh studding for reducing the sound in aircraft engines, in the ceilings of buses and motor cars, and in the field of refrigeration.

Savings of up to 30 per cent in fuel costs, as well as increased furnace life, have resulted from the use of vermiculite as a refractory for all types of hot-water tank boilers, kilns and furnaces. South African vermiculite has a fusion point of 1350° C., while the temperature at which it starts to sinter and undergo volume contraction is 1238° C.

During the war vermiculite was used in the United States for protecting buildings against incendiary bombs, for making bomb-proof decks, for packing bombs and shells, and as a substitute filling for life-belts.

Apart from the major uses of this valuable mineral, a wide range of miscellaneous applications has been developed. Both in the United States and in South Africa the suitability of the exfoliated material for use in oil refining has been investigated. In the foundry industry vermiculite is being employed as a foundry sand binder, mould facing and core wash. One of the latest applications is for the slow cooling of steel. On the Continent vermiculite is being used for fire-resistant paints.

The benefits of this remarkable mineral are by no means confined to engineering and building construction, for vermiculite is also being used to an ever-increasing extent for horticultural purposes. Although it is not a fertiliser, the exfoliated material has a favourable effect on soil growth. It is an ideal medium for conditioning soil, since it lightens and aerates the heavy clay type and aids sandy soil by holding water which would otherwise be lost. Vermiculite holds eight times its weight in water, which it dispenses slowly to the root system. Expanded vermiculite is so porous that it is almost impossible to drown plants growing in this material, and it can absorb and hold soluble fertilisers to a degree that humus cannot equal. Moreover, the intense heat to which it is subjected renders the expanded material completely sterile. Dry vermiculite also provides an ideal medium for the storage of bulbs and fruit.

In view of the rate at which the South African output is being expanded, there is every indication that Commonwealth production will be capable of keeping pace with the growing demands of the sterling area. No longer a 'dollar' mineral, vermiculite has become one of the few materials which, in view of the enormous reserves available, can nowadays be regarded as in virtually unlimited supply.

(*Since this article was written, a 70-page monograph entitled* Vermiculite *has been published by H.M. Stationery Office, price 7s. 6d. This document, prepared by Dr. E. R. Varley of the Mineral Resources Research Division, Colonial Geological Surveys, is the best survey of this subject yet produced.*)

A Technological University:

Can Britain Afford Anything Less?

THE problem of gearing science to Britain's industrial effort is a topic of practically non-stop debate. This is to be welcomed in so far as it shows recognition of the fact that science has a great deal to contribute to the solution of the problem of boosting productivity, and realisation that the flow of new discoveries and inventions has to be maintained if Britain is to hold her place in the development of technological industries. But abundant discussion of a specific set of problems continues to be valuable only so long as it is accepted as being the prelude to plans for action, and not as a substitute for action. Over the past ten years deficiencies in the organisation of British industry and British science have been analysed and docketed. Analysis and diagnosis there has been in plenty; now is the time for synthesis and prescription. The ideas of Britain's scientists and inventors need to be put into action on the full factory scale with ever-increasing speed and action, so that we can boost output and productivity, improve the quality of established products and create the new products which are required if Britain is to win the new markets which she must secure for reasons of sheer economic necessity.

It was evident that these points were appreciated when the House of Lords debated Lord Samuel's motion seeking information about Government policy with regard to the application of science in industry and agriculture, and also with regard to the more specific matter of the promotion of the higher education of technologists.

As we reported briefly in the last issue, the Government announced its support for the proposal that Britain's needs require the setting up of institutions comparable to the Massachusetts Institution of Technology. This was announced by Lord Woolton, who, as Lord President of the Council, is responsible for the D.S.I.R., M.R.C. and A.R.C. His exact words were:

"*The Government consider that a most important means of increasing productivity in industry is to improve facilities for higher technological education. They are convinced that this can best be done by building up at least one institution of university rank devoted predominantly to the teaching and study of the various forms of technology. We are, therefore, urgently exploring the practical possibilities as to the best way of doing this. As regards the last Government's White Paper . . . I should say that we fully recognise the important contribution which technical colleges can make to higher technological education, and details of our proposals for improving financial assistance available for selected colleges and courses will be shortly announced by the Ministry of Education. We do not, however, propose to establish a non-teaching, award-making body under the title of The Royal College of Technology.*"

The statement must be recognised as being rather a long way from the straightforward categorical statement of policy which at first reading it appears to be. It should be read in the light of Lord Woolton's remark to the effect that he could not "hold out any hopes of an immediate and dramatic increase in the facilities for the training of higher technologists to ensure that top-level men will be trained in the numbers likely to be required". It should be noted that the Government does not commit itself very far; for example, it has not gone so far as to state that it will take the steps leading to the creation of a British M.I.T. But if Lord Woolton took care to leave open a line of retreat in this matter, it may be said that Lord Cherwell, winding up the debate, stepped in and cut that escape route.

America's Technological Progress

Lord Cherwell explained the reasons why the Government favoured the idea of setting up at least one university of technology. He began his speech by stressing the importance of technologists in modern industries, contrasting the rate of increase of industrial productivity in Britain with the American rate. In the U.S.A., productivity has increased by 3% per year, as against 1½% in Britain, and this big difference Lord Cherwell attributed to the fact that the U.S.A. has three times as many highly trained technologists as Britain. Figures of this type reveal only part of the picture, as Lord Cherwell was careful to stress when he mentioned certain other significant factors which put America in a more advantageous position than Britain. He reminded the peers that with an expanding economy associated with an expanding population like America's, new factories are needed, and these can be brought into operation with the most modern equipment. Another feature of the American industrial scene is the practice of working several shifts a day; where machinery is operated right round the clock then the latest machinery, which tends to be the most expensive, can be installed in the knowledge that it will be exploited to the full and operated 24 hours a day. U.S. reliance on private enterprise was the third factor which Lord Cherwell considered to be relevant, though he did not press the point home, presumably because he did not want to risk introducing a strongly controversial element into the debate—which was a pity in some respects for the financial questions affecting the exploitation of science and technology cannot be resolved by ignoring them; they require to be brought to the nation's notice, for it must be more generally realised that every new discovery and every new invention worth developing calls for someone to take a big financial gamble at some stage and decide to start factory production.

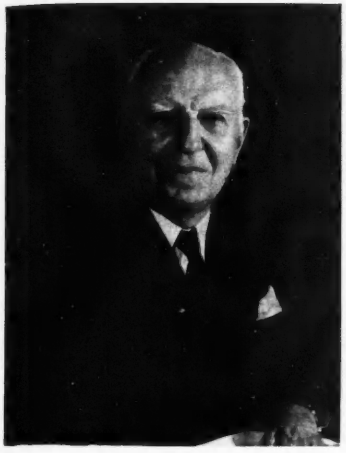
Lord Cherwell's argument in favour of a new technological university was extremely simple; he relied on the technique of showing there was no other practical alternative to the setting up of a technological university.

Can a technological university of the kind required to meet Britain's needs emerge from the expansion of an existing technical college as some people have suggested? Lord Cherwell did not consider that this line offered a satisfactory solution. By their nature, technical colleges are *poly*technics, teaching many things besides scientific and technological subjects, and Lord Cherwell stressed the fact that to upgrade such technical colleges in an attempt to convert them into technological institutions of university rank would necessitate separating the scientific-technological subjects from the others; in other words, there would have to be separation of the two kinds of students into two different streams. Others have argued against the M.I.T. project, favouring instead the expansion of technological departments already existing in universities. Lord Cherwell disposed of that proposal with these words:

"*The short answer is that you need so much paraphernalia to teach technology properly in the various branches (and of course I include textile technology, which I think is extremely important) that you cannot afford to do it unless you have 3000 or 4000 students, and in a large number of universities you cannot have that number of technologists. Therefore, if you say you are going to teach it merely in the universities you will tend either to have too little apparatus or to be incredibly extravagant.*"

Lord Cherwell reached the proposal for setting up a British counterpart of M.I.T. by the process of eliminating all alternative propositions, and if his logic was somewhat ruthless it was the inexorable logic of a man who has full faith in what he proposes and no faith at all in any of the counter-proposals. The M.I.T. solution is the one favoured by most of our top-grade industrial technologists, men who are of the type which Britain will need in ever-increasing numbers, and Lord Cherwell spoke with the conviction of a man who knows that those best qualified to judge this issue support this line.

There was some discussion as to whether Britain's M.I.T. should come under the University Grants Committee, or under some new committee specially created to take care of higher technological education. Lord Cherwell was emphatic that the University Grants Committee was the right body to look after technological universities, indeed he thought it *essential* that the U.G.C. should be made responsible, in order to emphasise and guarantee



LORD WOOLTON

"We are actively exploring . . ."

the university status of the new university, which would be able to give degrees and have all the rights, privileges and freedom of a university.

Earlier we described Lord Woolton's statement as not committing the Government very far. It is essential to realise this point which stood out very strongly when Lord Cherwell was forced to admit to questioners that the Government has not decided how Britain's first technological university will be created. Lord Samuel had asked whether it would be "a wholly new institution, or a development of one of the existing institutions, or a combination of them". Lord Cherwell replied that those were exactly the sort of questions now being studied by the Government; in fact he went so far as to say that how the problem of establishing the first technological university is *to be attacked* is still at the moment very much under discussion. The Lords were clearly not happy about the lack of detailed information on this point, and when one remembers that *seven years* have now elapsed since the authorities first started to examine the question of meeting Britain's need for more technologists trained to M.I.T. standards, their obvious impatience at this lack of satisfactory information was scarcely surprising!

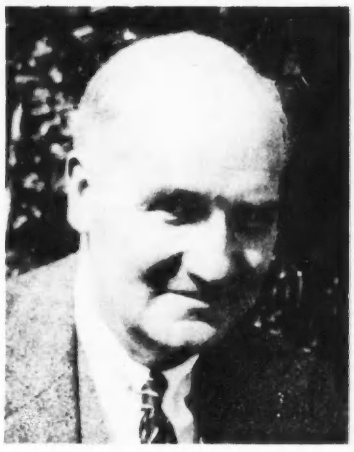
The Dearth of Science Masters

The shortage of first-class technologists is one of the important factors limiting the exploitation of scientific and technological knowledge in industry. The setting up of a new technological university and the expansion of certain 'technological colleges' would largely rectify that deficiency, but the development of these twin projects would itself be hampered if the schools of Britain failed to turn out properly educated students of the right calibre who could benefit from increased opportunities for higher technological education. Here the limiting factor is undoubtedly the availability of good science masters. That there is a dearth of such masters is obvious from the very fact that many schools have had to drop scientific subjects from their curricula simply because they cannot get staff. The matter was raised in the Lords' debate, and it is somewhat surprising to realise that although the peers felt able to cope with the problem of finding a practical answer to the shortage of technologists they made no attempt to offer any comparable solution to the problem of finding sufficient science masters.

Lord Samuel's motion was not of such a type that it could be pressed to a division. Nevertheless, one gained the impression that the majority of the peers who took part in the debate were in favour of the M.I.T. proposal. It is, of course, possible to analyse the speeches and decide whether individual peers favoured the M.I.T. proposal though it was evident in some cases that individual peers intended to remain silent on this particular point for reasons of discretion. (Quite a few of the peers have close connexions with scientific and professional organisations, or are associated with the committees and councils concerned with Government science, so it can be appreciated that there are many matters about which they must be discreet; the M.I.T. project seems to be one of them.)

The peer who started the debate was Lord Samuel, whose wide interest in scientific subjects will be well known to readers through his lectures and such writings as his recent book *Essays in Physics*. He is the present President of the Parliamentary and Scientific Committee, the unofficial body which is composed of 123 M.P.s, 36 peers and representatives of 74 scientific organisations, and which is one of the main links between the politicians and the world of science and technology. Lord Samuel did not come out definitely in favour of the M.I.T. proposal, but he evidently thinks highly of M.I.T. itself judging from his remarks about this establishment which he visited recently. He spoke with obvious approval of the fact that M.I.T. makes its students spend about a fifth of their time on the arts and humanities, saying that M.I.T. regard it as their business to humanise their scientists whereas Harvard University set out to scientise their humanists.

Viscount Hall, a Labour peer who left an elementary school to become a collier, and who appreciates the value of higher education in the way that only those who have been denied such an opportunity can, favoured expansion of technological departments of existing universities. He wanted to see Manchester College of Technology and the Royal Glasgow Technical College upgraded (in actual fact these two colleges train students to degree standard: the students obtain *internal* degrees of Manchester and Glasgow universities respectively; but neither has the full rights and privileges of a university). Lord Hall gave figures for the number of students taking university degrees through technical colleges; the total was 8770 full-time students and 11,200 part-time students, and Viscount Hall thought that such students would be much encouraged by the speedy fulfilment of the plans outlined by Lord Woolton.



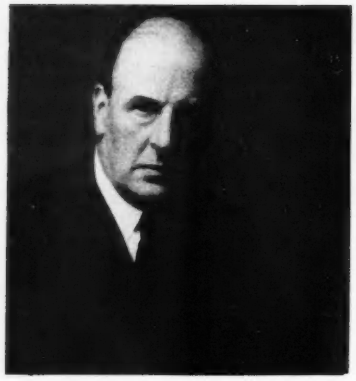
LORD CHERWELL

The Government's chief scientific adviser saw no alternative to a British M.I.T.

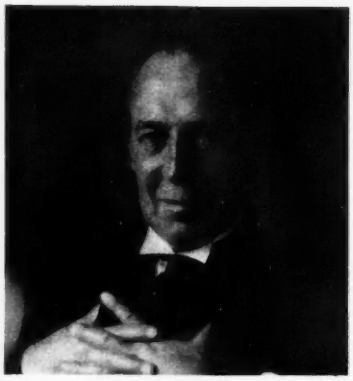
Lord Waverley, whose title cloaks the personality better known to most people as Sir John Anderson, originally took a B.Sc. in chemistry and afterwards did research in Germany; he has knowledge of various technological industries through service on boards of directors, and during the war was concerned with the atomic bomb project on the organisational side. He favoured the M.I.T. project, but saw the upgrading of "the best and most promising technical colleges" as the swiftest means of obtaining more high-grade technologists. (Incidentally, the term 'technical college' proved an unsatisfactory term in the debate because the status varies from college to college: Lord Waverley presumably was thinking of such colleges as those at Manchester and Glasgow, to which the term 'technological colleges' might usefully be applied.)

The technical colleges that were raised to university standard should be detached, said Lord Waverley, from the ordinary educational system of the country and put in the position of universities, receiving their assistance through the University Grants Committee. There would still be room for one or more M.I.T.s. With regard to the shortage of science masters he said that "unless that deficiency can be made good, no development to which one can look forward in the organisation of teaching institutions can be fully effective".

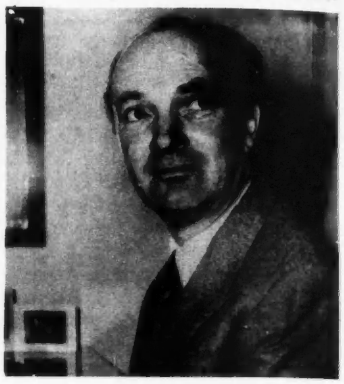
Lord Brabazon, who has interests—commercial as well as technical—in the aircraft, automobile, radio and photographic industries, spoke of shortages of technologists and of technicians right through industry. He maintained that for the money spent by the nation we are not getting the right proportion of people following up from technician to technologist, and up to scientist. Too many



LORD BRABAZON



LORD WAVERLEY



LORD HALSBURY

promising young technicians go into dead-end jobs rather than do two or three years more education. "I make the suggestion that industry should give a guarantee, firm by firm, to colleges—or should invent some machinery whereby they can do it—that they will take a certain proportion of these boys from these technical colleges, because they have just as great a responsibility as the State has. I consider that the State has roused itself and done important work in this development, and it now rests with industry to play its part to see that our money is not wasted."

Technological advances affect workers and can lead to serious unemployment when the introduction of new machines displaces large numbers of operators. Lord Crook struck a salutary note by presenting the trade union attitude to technological advance. He emphasised the need in modern industries for the two sides of industry to reach genuine agreement; without it, scientific development cannot be exploited to the full. Lord Crook stressed the vital importance of the development stage that comes between laboratory discoveries and factory production. He himself favoured development councils as a means of ironing out difficulties arising when new processes and plants are being brought into operation, and regretted the antagonism which, he said, employers have shown to development councils.

Lord Halsbury is a peer who has met many scientists and technologists since 1949 when he became managing director of the Government-sponsored National Research and Development Corporation. A scientist by training, he has had experience of at least one technological industry from the inside. He is also a vice-president of the Parliamentary and Scientific Committee. He expressed no view on the M.I.T. project, concerning himself mainly with regrets that the D.S.I.R. could not get buildings and expand its research capacity.

Lord Strabolgi, who did not commit himself on the M.I.T. proposal, has special knowledge of science in naval warfare and pleaded for closer liaison between the Services and scientists. He suggested that in the Navy at least one member of the Board of Admiralty should be a scientist of very high attainments. In the Cabinet one man with knowledge of scientific matters was needed, like Lord Cherwell, he said.

Lord Caldecote, who has been a lecturer in the Engineering Department of Cambridge University and an assistant manager of a naval shipyard, was in favour of a British M.I.T. He said, "I hope that the new technical university which is to be set up will not be started from scratch, but will be based on one of our present universities—perhaps the Imperial College in London, or one of the great Midland universities." He was against simply turning technological colleges into universities because we wanted more people to have degrees; that approach he saw as leading to debasement of degrees. "But if the technical colleges are turned into universities because they have earned it, and the men there have earned it, that surely is the way it should be done. If it is done in that spirit I would welcome the move wholeheartedly."

Lack of Buildings

University engineering departments had done much to meet present needs, said Lord Caldecote; he thought they had increased their output of graduates by at least 50 per cent. But expansion here was hampered by lack of buildings. Moreover, the university technological departments could only expand if sufficient students were prepared to take the courses. "I believe that a good deal of propaganda is necessary in the schools just as it is in management, to overcome the old-fashioned idea that a man with a technical education is not educated although a man who has had a classical education, with no science, is. I am sure that much could be done by propaganda in the schools to encourage boys to think that a technological career is a first-class career, as good as one in what is normally called business, which will reward them with as great responsibilities and as good jobs."

Lord Calverley, who is actively concerned with adult education, spoke of the support given to the M.I.T. proposal by the Education Committee of the Association of Municipal Corporations. He regretted that great technical institutions in Britain (he had previously mentioned the technical colleges of Huddersfield and Halifax) have been treated like Lazarus, getting only the crumbs let fall by the University Grants Committee. . . . "If there is a vested interest to look after the universities they will go on doing it," he added.

The technical institutions are suffering, said Lord Calverley, from a sense of frustration. "The Lord President of the Council, fills me with a great sense of happiness in looking forward to brighter times for our technical colleges. We want these men or women in our chemistry departments in the textile trade. If they can prove that they are worthy of a degree they should not be fobbed off with a certificate, or something like that," he concluded.

Lord Stamp supported the M.I.T. proposal. But he thought for immediate results we must rely on strengthening and expanding existing university departments and raising standards of technological education generally. In selecting those technical colleges most suited for expansion for higher technological education, one of the most important considerations, apart from their present status, should be their proximity to a university, and the opportunity for increased association with it, since only in this way can its students hope to gain a broad background of contacts, learning and cultural interests.

He suggested forming a committee to do for technological education what the University Grants Committee does for the universities.

Lord Webb-Johnson, the distinguished surgeon, was uncompromising about the need being for top-grade technologists. A lack of such men largely accounts for the time-lag between laboratory bench and factory bench. "Those countries who are our most serious rivals have produced their technologists from separate institutes. In those institutes they are given a wider curriculum than is required just for the training in technology. They have had some general scientific and social background as well as the background and knowledge for their calling. Their training has been broad based, and it is axiomatic that a man who has been broadly

trained passes more easily into the development of a specialty than one who has been trained in one narrow specialty and then attempts to switch to another."

The technological university must have complete freedom, administratively, financially and academically, said Lord Webb-Johnson. He thought it could not come under the University Grants Committee which is already overloaded, nor under the Ministry of Education. "Let a bold step be taken and let a special department be created to deal with this problem. . . . I believe—for it is the experience in medicine and surgery—that the diploma of the institute will soon acquire a prestige perhaps even higher than the highest awards of the universities."

Lord Falmouth wanted more high-grade technologists—and also more high-grade technicians of national certificate standard. "For every high-grade technologist, in some industries, at least, you require forty technicians in order to maintain a balanced output," he remarked. Without claiming that the Imperial College of Science and Technology is the exact counterpart of M.I.T., he pointed out that I.C.S.T. does exchange professors and post-graduate students with M.I.T. Lord Falmouth has been closely associated with I.C.S.T. and not unexpectedly he maintained the standard of education at I.C.S.T. was no lower than that of M.I.T., though he did not discuss the comparable scope of the two curricula.

Lord Chorley, a lawyer who is associated with the London School of Economics, seemed to be speaking for the Association of University Teachers. He wanted to see technologists become leaders of industries and not be just technical experts. He said it would take decades to create an M.I.T., and favoured instead expansion of university technological departments. This would require "absolute A1 priority [for building] laboratory accommodation". He expressed doubt about upgrading "a few of the technical colleges up and down the country". Of Manchester College of Technology he said it was already a university in all but name, and so was that at Glasgow. If technical colleges were upgraded, they must specialise in producing technologists; it was impossible to train both technologists and technicians in the same institution. He said that low salaries are already leading to depletion in the staffs on the applied science side in the universities. "The assistant lecturer who is now recruited to a university staff is being paid slightly below the Burnham scale for a master in a secondary school. Until that situation is righted, there will continue to be real difficulties in the universities," he added. At the end of his speech Lord Chorley conveyed the impression that he considers that industry creams off the best scientists, leaving the residue for the universities and Civil Service research establishments.

Far and Near

Night Sky in August

The Moon.—Full moon occurs on August 5d 19h 40m, U.T., and new moon on August 20d 15h 20m. The following conjunctions with the moon take place:

August				
4d 18h	Mercury in conjunction with the Moon		Mercury	6·4° S.
12d 17h	Jupiter	,,	Jupiter	7° S.
19d 12h	Mercury	,,	Mercury	4° S.
22d 06h	Venus	,,	Venus	4° N.
24d 15h	Saturn	,,	Saturn	7° N.
28d 05h	Mars	,,	Mars	3° N.

The Planets.—Mercury is in inferior conjunction on August 12 and cannot be observed during the first part of the month; towards the end of August it is a morning star, rising at 3h 30m on August 31, its stellar magnitude then being about 0. Venus is an evening star, rising at 20h 15m, 19h 55m and 19h 25m on August 1, 15 and 31, respectively, and can be seen for a short time after sunset, stellar magnitude about −3·3.

Mars, an evening star, sets at 22h 30m, 21h 55m and 21h 15m at the beginning, middle and end of the month respectively. The planet recedes from α Librae, moving eastward until it is a little south of β Scorpii at the end of August; its stellar magnitude varies from 0 to 0·3 during the month. Jupiter rises at 23h, 22h 10m and 21h 10m on August 1, 15 and 31, respectively, and cannot be mistaken as its stellar magnitude is about −2 and it is nearly 3° south of δ Arietis during most of the month. Saturn sets two hours after the sun at the beginning of August and just over an hour after the sun at the end, stellar magnitude 1·1. The planet will be seen to move in an easterly direction from γ Virginis to a little north of θ Virginis during August.

The Perseid meteors will be active from about August 10 to 12 though meteors connected with this shower can be seen —though not in such profusion—before and after these dates.

There will be a partial eclipse of the moon on August 5, partly visible at Greenwich. The moon enters the penumbra at 17h 26·6m and the umbra at 18h 33·4m, the middle of the eclipse occurring at 19h 47·4m. The moon leaves the umbra at 21h 01·4m and the penumbra at 22h 08·2m. Only about half of the moon's diameter is eclipsed. On August 5 the moon rises just before 19h 45m which is close to the time of the middle of the eclipse. The sun sets on this date a few minutes after 19h 40m and owing to twilight for some time after sunset the lunar eclipse will not be very spectacular, but it will be worth looking at. Just over a fortnight later there is an annular eclipse of the sun, but this eclipse, which occurs on August 20, is invisible at Greenwich or indeed anywhere on this side of the Atlantic. South America will, however, have a good view of it!

Glasgow's Industrial Physics Exhibition

THE new EM4 electron microscope produced by Metropolitan-Vickers Electrical Co. Ltd. of Trafford Park, Manchester, 17, was on show at the fourth in the series of Industrial Physics exhibitions organised by the Institute of Physics, which was held in Glasgow this June. This 55-kV electron microscope is based on experience accumulated from the well-known types EM2 and EM3 electron microscopes, but bears no physical resemblance to its predecessors. It has been designed particularly as an inexpensive instrument for routine work in factory or laboratory, providing magnifications up to 12,000, with a resolution better than 100 angstroms. The whole instrument is enclosed in one cubicle, and is equipped with simple plugs for connexion to standard factory electricity mains.

Metro-Vickers also exhibited an interesting model of the 300-h.p. gas-turbo-electric locomotive for British Railways, the first of this type of engine to be put in hand in this country, which is now in service on British Railways, Western Region. A six-axle loco, 66 ft. 9 in. long and weighing 130 tons, this has a maximum service speed of 90 m.p.h. The gas turbine is a simple open-cycle plant in which a five-stage turbine drives the compressor and the generators. There is no heat exchanger, and a light and compact design has been achieved. The straight-through combustion system comprises six flametubes, one or more of which can be removed to give access to the inboard bearings.

A piece of equipment on show which has widespread applications was the Metrovac twin-tank high-vacuum coating plant, designed to produce a thin film of a desired substance on a selected base material, when chemical and/or physical methods are inapplicable. The complete plant consists of two similar vacuum tanks arranged one at either end of a common control desk. The equipment is self-contained, all vacuum pumps, transformer contactors, protective equipment and controls being located thereon or therein.

Mullard Ltd. put on a demonstration which attracted much attention, of the use of their recently developed ME1201 grid-controlled image converter which can be used as an ultra high-speed shutter in a camera capable of giving exposures of the order of 10^{-8} second—one-hundred-millionth of a second. This tube has already made possible considerable advances in the field of high-speed photography. So far it has been mainly used in the study of self-luminous phenomena such as explosives and discharges in gases, but it has numerous possibilities in other fields of research. The image-converter technique should prove of value in the study of many rapid events where exposures of less than a microsecond are needed to arrest motion. Examples of these may be found in cavitation

phenomena, high-pressure fuel jets, and stress waves in solids. Mullard also showed several ultrasonic devices, including a low-frequency magnetostriction ultrasonic generator, which utilises a magnetostriction transducer and is capable of being used on physical, chemical and metallurgical investigations. The frequency range is from 15 to 25 kilocycles, and the power output is as follows: Type E7590A, 1 kilowatt; Type E7590B, 500 watts; and Type E7590C, 250 watts. This firm also makes to order, high-power generators for use with large or multiple bank magnetostriction transducers; these units are designed for industrial applications and have outputs in the range of 5 to 50 kilowatts.

Terramycin *v.* Pneumonia

PNEUMONIA, still a most dangerous disease to babies, has been treated with dramatic effectiveness with one of the liquid forms of terramycin, one of the newer 'broad-range' antibiotics, according to two child-health specialists at the Manchester University, Drs. B. Wolman and A. Holzel. Sixty-six patients suffering from pneumonia and other childhood infections at the Duchess of York Hospital for Babies at Manchester were included in clinical tests conducted with the antibiotic by these researchers. The result, they state, was a "rapid and dramatic response. Thirty-four out of thirty-five patients with pneumonia responded rapidly to treatment, in most cases within 24 hours".

Terramycin, given orally in one of its liquid preparations, was also found to bring 'dramatic response' in treating children and infants with upper respiratory tract infections including those of the tonsils, throat, nose and middle ear. Pyuria responded equally well.

Describing their work in the *British Medical Journal*, they report that terramycin was the only therapy used in these cases. They add that the taste of the medicine is a very important factor in treating children, so the terramycin was incorporated in a cherrymint-flavoured elixir and administered in that form in this set of tests. They comment that the elixir proved "extremely palatable, and no difficulties were encountered in its administration. In fact, ward sisters preferred its use to the other antibiotics because it was taken so readily by infants and children." One great advantage of this antibiotic demonstrated by these tests was the absence of harmful side-effects.

Terramycin's effectiveness in treating pneumonia in infants and children seems to be of major importance in view of the great number of victims this infection has claimed. In 1948, pneumonia claimed more lives than any other disease in the one-to-four age group in Canada, Britain, Ireland, Australia and the Union of South Africa.

Four I.C.I. Scientists win M.I.T. Scholarships

THE Massachusetts Institute of Technology awards four scholarships a year for its special summer course to British post-graduate research workers. This year I.C.I. scientists have swept the board. Three of the scholarships go to representatives of the Billingham Division; these are Dr. J. F. Brown and Dr. L. V. Johnson (Physical Chemistry Research Group, Research Dept.) and Dr. A. J. P. Tucker (Engineering Research Group, Chief Engineer's Dept.). The fourth member of the party is Dr. A. J. Ellerman from I.C.I.'s Paints Division.

The scholarships are awarded under the Foreign Students Summer Project run by the Students Committee of the Institute. Competition is keen, and the numerous applications are considered by a committee organised by the American Embassy in London, comprising representatives of British university and industrial research bodies and American consular officials. This committee carries out the interviewing and the final selection is made by the Institute in Boston. To qualify for the scholarships, which are open to non-Americans all over the world, applicants must have completed a total of three years' research work in university and industrial fields and must also be athletes. The aim of the Summer Project is to give the eighty scholarship winners a general picture of work similar to their own at present being undertaken in the United States. The course lasts from June 2 to September 12 this year.

Utilisation of Solar Energy

THE possibilities of utilising solar energy have been investigated by a sub-committee appointed by the director of the National Physical Laboratory. The sub-committee, which is preparing a report on this subject, includes Professors P. M. S. Blackett, F. G. Gregory, E. A. Guggenheim, W. R. Hawthorne, Dr. H. Heywood, Willis Jackson, F. E. Simon, and Dr. H. Heywood.

Oil Pollution and Sea-birds

AN increasing tendency to carry out thorough scientific surveys before formulating policy was evident at the Fifth Conference of the European Continental section of the International Committee for Bird Preservation, held at Bologna, Italy, in May. This was especially noteworthy in the sphere of the danger to sea-birds from oil pollution; surveys have been conducted in both Britain and Holland to find out what kinds of sea-bird are most affected, and an investigation has been made by the Government Chemist in Britain to determine the kind of oil which is causing the trouble.

Preliminary results of the survey of oiled birds, carried out in Britain by the Royal Society for the Protection of Birds, and in Holland by the Netherlands Section of the I.C.B.P., may be summarised as follows:

Britain.—When the figures for the number of birds killed or significantly affected by coming into contact with oil-polluted water were analysed, the gulls were found to be the most common victims—70% of the total number of birds recorded in this survey were gulls. Other kinds of birds involved were: guillemot (11%), scoters (9%), razorbill (5%), red-throated diver (2·5%), grebes (1%).

Holland.—The Dutch survey gave the following percentages: guillemot, 45–50; razorbills, 15–20; divers, 10–15; scoters, 8–12; gannet, 5–10; kittiwake, 5.

It is now generally accepted that everywhere the diving birds, auks, grebes, divers and diving ducks suffer severely from oiling. It is believed indeed that a general decline in the numbers of breeding guillemots and razorbills is attributable to this cause. In Britain it is estimated that a total of somewhere between 50,000 and 250,000 birds perish every year, from pneumonia and exhaustion, after settling on oil-coated water. The exact nature of this floating oil is now known as a result of analysis by the Government Chemist. Oil from the feathers of birds found dead on the beaches proved to be fuel oil, pumped out of bilges and forming a film on the water. This disposed of the frequent allegation that since the war much of the oil had come from tankers sunk during the war. On the other hand the oil that fouls so many beaches in various parts of the British Isles was found to have a quite different origin. This oil occurs in hard lumps, and appears to originate from the bottoms of tankers. It contains a high proportion of a commercially valuable wax, and it is hoped before long to find a commercial outlet for it; this might help towards the ending of this particular nuisance. A parliamentary committee under the chairmanship of Mr. L. J. Callaghan, former Parliamentary Secretary to the Ministry of Transport, has been taking an active interest in this question, and has secured the co-operation of the oil companies.

International measures for the protection of wildfowl are similarly being placed on a scientific basis—by the gathering, for the first time, of winter-population statistics of ducks and geese for most countries of Western Europe by the International Wildfowl Research Institute. In this connexion counts are being carried out in France, Germany, Holland and Denmark, as well as in the British Isles; in Germany much of the information has been contributed by officers of the British Army of the Rhine. This investigation originated as an attempt to study the decline in the numbers of wildfowl throughout Western Europe, to which attention was first drawn by the eminent Swedish ornithologist, Professor Lönnberg, some twenty-five years ago. While the numbers of most wildfowl have declined, none of the decreases has been catastrophic except that of the brent goose, which probably followed the virtual disappearance of *Zostera*, the bird's staple diet, from the coasts of Europe. A most striking feature of the present distribution of ducks is that the largest numbers are now often to be found, not in remote coastal areas, which the advent of the motor-car has made so much more accessible to sportsmen, but on large reservoirs in the neighbourhood of towns, where they are safe from this kind of disturbance.

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